

Machine Detector Interface

Karsten Buesser
DESY



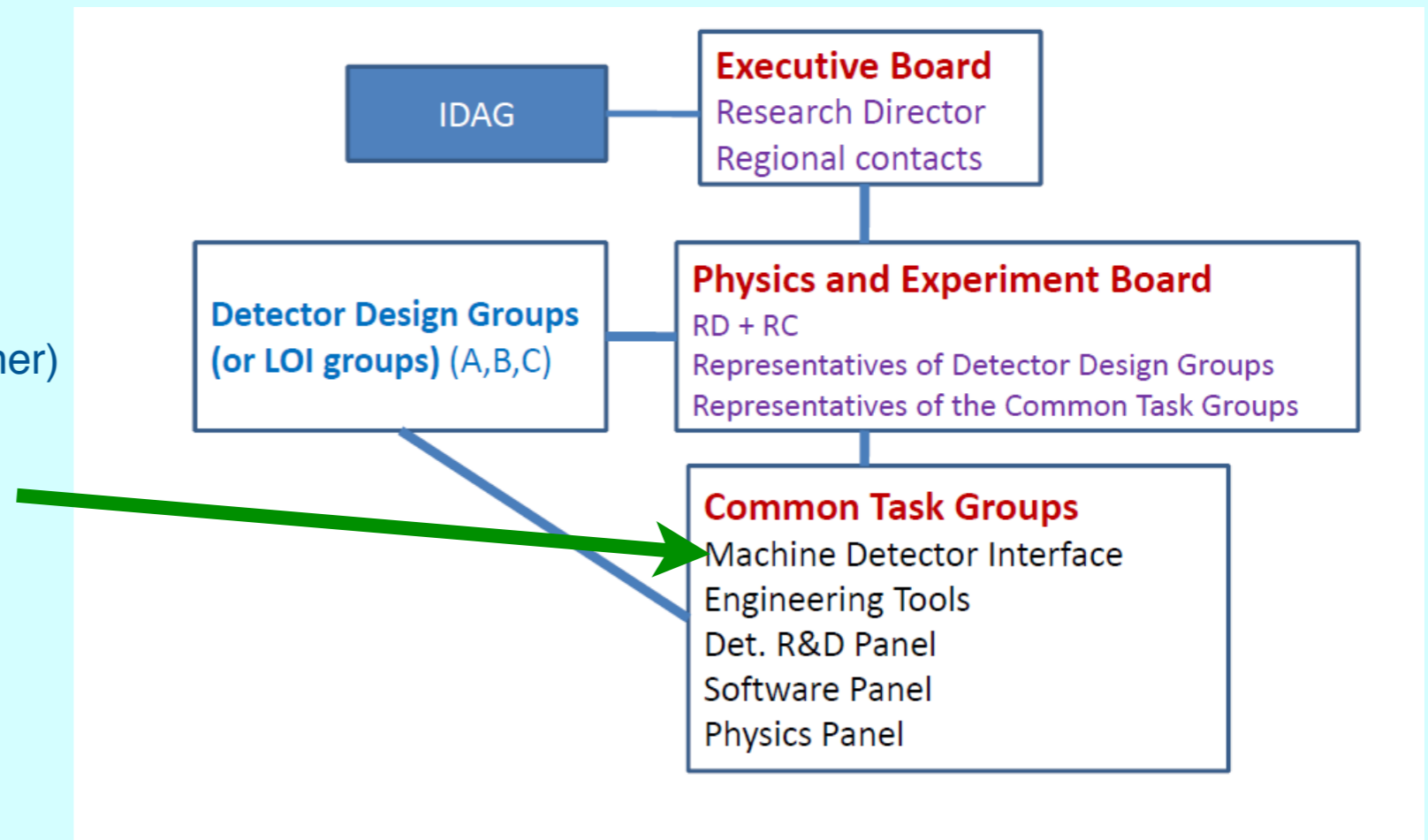
ILC Project Advisory Committee
Eugene, OR
12 November 2010

1. The ILC Machine-Detector Interface Organisation
2. Push-pull System Design Study
 - a. Detector Motion System
 - b. Underground Hall Design
 - c. Detector Assembly and Integration
 - d. Detector Services
 - e. Final Doublet Magnet Developments
 - f. Alignment Systems for Final Doublet Magnets and Detector Elements
 - g. Vacuum System Design
 - h. IR Feedback System Design
3. Conclusions and Outlook

- Common task group of the Research Director's organisation:

- **Members:**

- K. Buesser (DESY, convener)
- P. Burrows (Oxford, dep. convener)
- A. Hervé (ETH Zürich)
- T. Markiewicz (SLAC)
- M. Oriunno (SLAC)
- T. Tauchi (KEK)



- Usually meets in phone meetings (~ monthly)
- Close contact to the GDE BDS group
 - A. Seryi participates regularly in the phone meetings

IR Interface Document

ILC-Note-2009-050
March 2009
Version 4, 2009-03-19

Functional Requirements on the Design of the Detectors and the Interaction Region of an e^+e^- Linear Collider with a Push-Pull Arrangement of Detectors

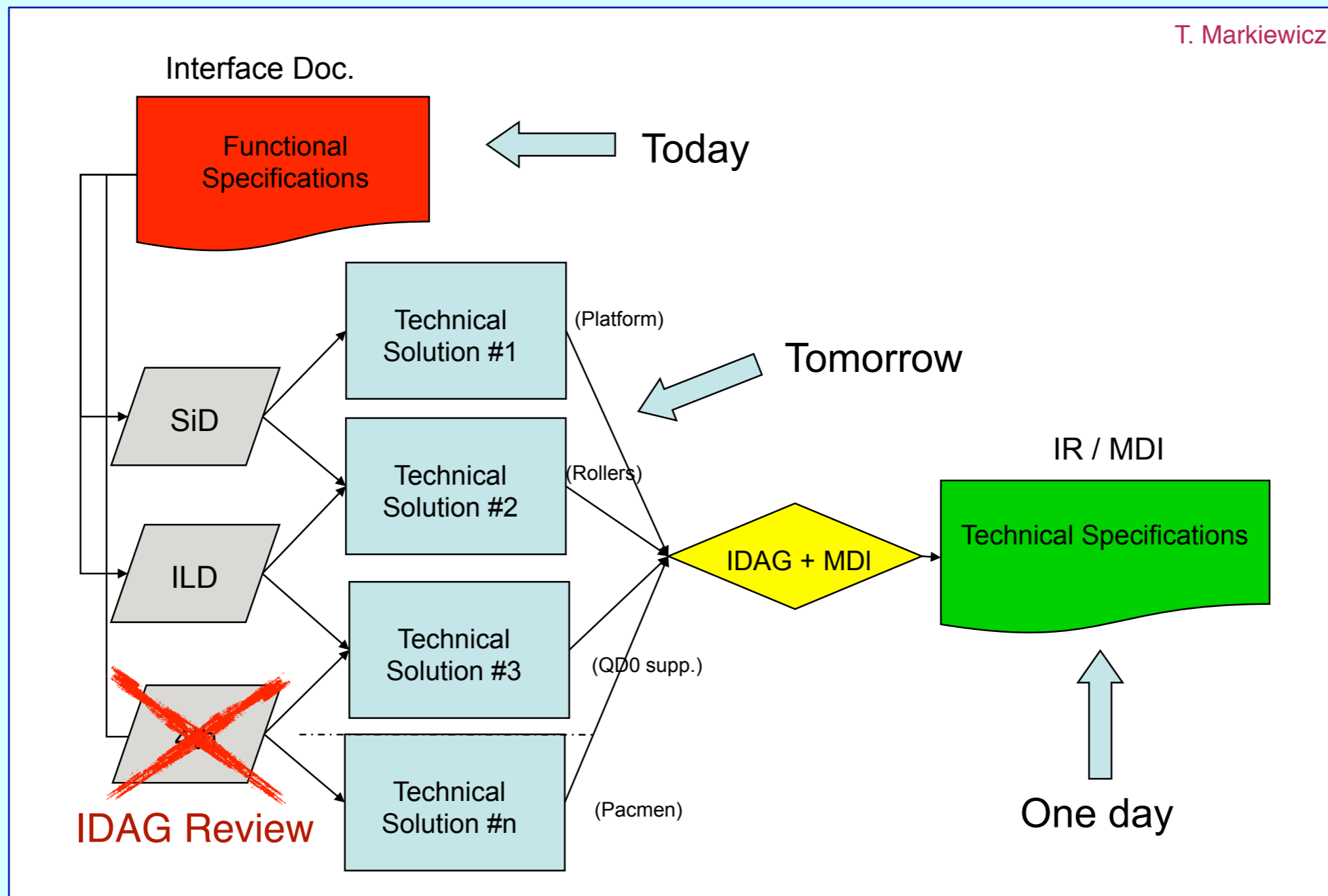
B.Parker (BNL), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY),
J.Hauptman (Iowa State Univ.), T.Tauchi (KEK), P.Burrows (Oxford Univ.),
T.Markiewicz, M.Oriunno, A.Seryi (SLAC)

Abstract

The Interaction Region of the International Linear Collider [1] is based on two experimental detectors working in a push-pull mode. A time efficient implementation of this model sets specific requirements and challenges for many detector and machine systems, in particular the IR magnets, the cryogenics and the alignment system, the beamline shielding, the detector design and the overall integration. This paper attempts to separate the functional requirements of a push pull interaction region and machine detector interface from any particular conceptual or technical solution that might have been proposed to date by either the ILC Beam Delivery Group or any of the three detector concepts [2]. As such, we hope that it provides a set of ground rules for interpreting and evaluating the MDI parts of the proposed detector concept's Letters of Intent, due March 2009. The authors of the present paper are the leaders of the IR Integration Working Group within Global Design Effort Beam Delivery System and the representatives from each detector concept submitting the Letters Of Intent.

- Common document of the MDI-D common task group together with the GDE-BDS group
- Definition of the functional requirements to allow a friendly co-existence of two detectors and the ILC machine in a push-pull scenario
- Provide a set of ground rules, not technical solutions to the problems!

- Document has been discussed in detail between the MDI-D and the GDE-BDS groups
- Approved by concept groups, BDS technical area leaders and PM for accelerator systems
- Published as ILC-Note-2009-050



Design Study for the Interaction Region Push-Pull System for the ILC

Authors

A. Seryi (SLAC), K. Buesser (DESY), P. Burrows (Oxford), A. Hervé (ETH Zurich), T. Markiewicz (SLAC), M. Oriunno (SLAC), T. Tauchi (KEK)

Motivation

The Interaction Region push-pull system represents one of the most technically challenging areas of the ILC, whose performance may determine the success of the entire collider. Challenges range from civil construction to detector sub-system performance. Design of the push-pull system is progressing; however, the complexity of the problem requires enhancement of the current efforts. In particular more support for the engineering design of the components is needed in order to arrive to a mature design before the end of 2012. Besides the clear alignment of the work to the ILC Technical Design Report, it should be noted that synergies are expected to come from close collaboration with similar efforts in the CLIC collaboration.

Current Status of Work

The push-pull arrangement of detectors is not a new idea; however, it was never realised in practice to the extent required for ILC in terms of reliability and efficiency. For ILC, the push-pull arrangement was evaluated on the conceptual level in 2006, and while it has been determined that the technical issues have conceptual solutions, it was deemed that “careful R&D and engineering studies will be needed during the TDP time to validate and optimize the proposed configuration”, as stated in the GDE push-pull Configuration Change Request (CCR) to the ILC baseline approved in early 2007.

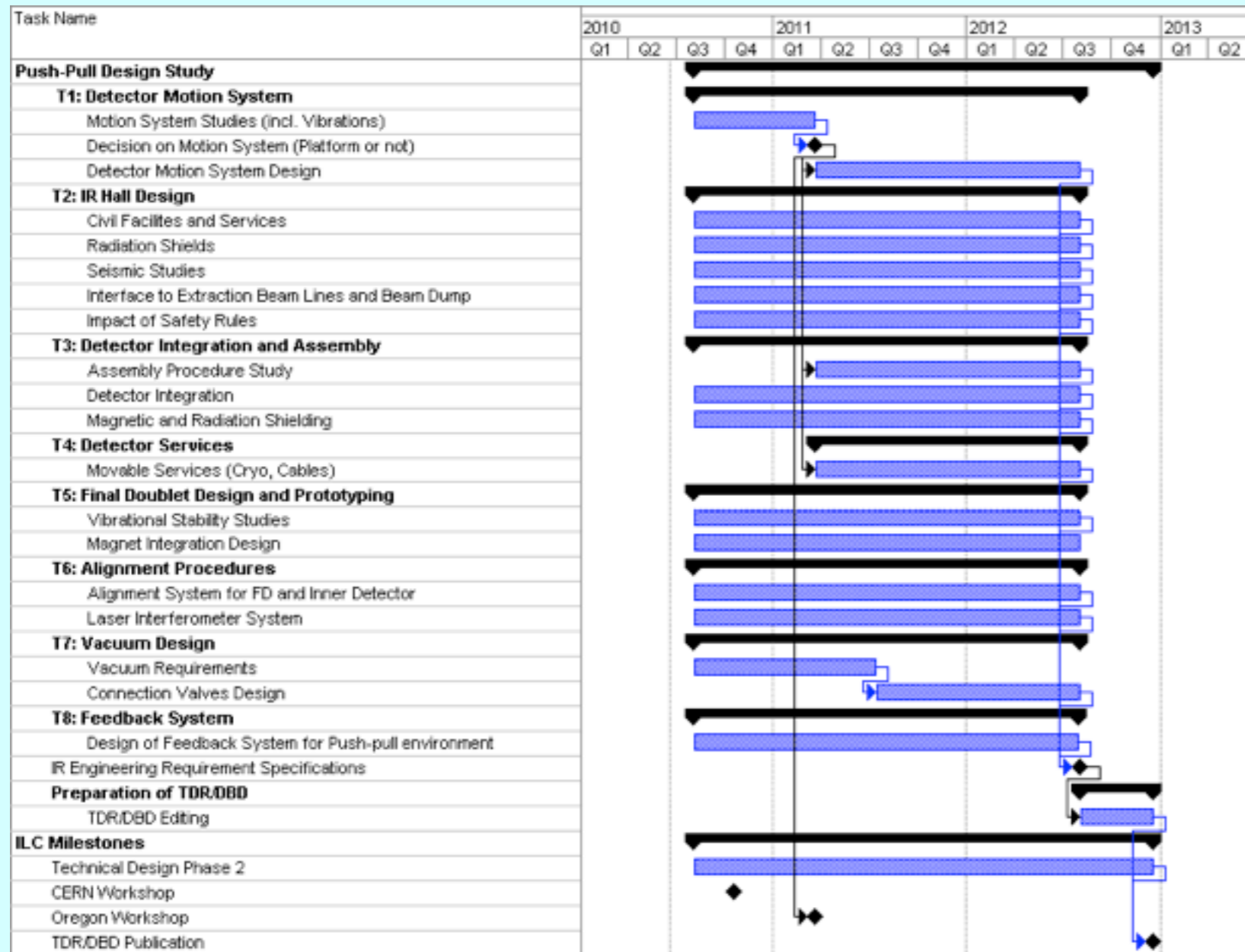
Interrelation of technical challenges for the push-pull system is best expressed and grasped pictorially as an interrelation diagram (c.f. Figure 1).

- Most important topic in ongoing MDI work is the design of a realistic push-pull system for the detectors
- Push-pull design study proposal:
 - Originated in request by ILCSC:
 - Offered help to find additional engineering resources for detector developments and push-pull design
 - MDI group prepared a proposal for a design study on the push-pull system
 - Submitted to ILCSC by B. Barish and S. Yamada in July 2010

Identified Tasks:

1. Design of the detector motion system; study of its vibration properties in simulation and experiment.
2. Design of the IR underground hall for push-pull, including facilities and services for the operation of the detectors, radiation shields, seismic issues, impact of safety rules.
3. Optimisation of the detector integration and its impact on assembly procedures, magnetic and radiation shielding, vibration sources.
4. Design of detector services supplies for push-pull (data and HV cables, cryogenics).
5. Design and prototype of the final doublet quadrupoles and verification of their stability.
6. Design of alignment system for the final doublet magnets and the inner detector components, including the design of a laser interferometer system.
7. Study on IR vacuum design, including vacuum requirements and design of quick connection valves.
8. Study of intra-train feedback systems in a push-pull system.

Push-pull Design Study Proposal



- **Critical milestone: decision on common detector motion system by March 2011**

- Estimated resources over two years:
 - at 14 institutions
 - Existing:
 - ~9.25 FTE (best estimate)
 - Requested new:
 - 14.5 FTE
 - 1.5 FTE out of those are recently supported by KEK for detector integration and hall design
 - CERN is taking relevant steps towards a contribution of 2 FTE
 - Waiting for more
- Programme is under progress with existing resources, re-scoping might need to take place

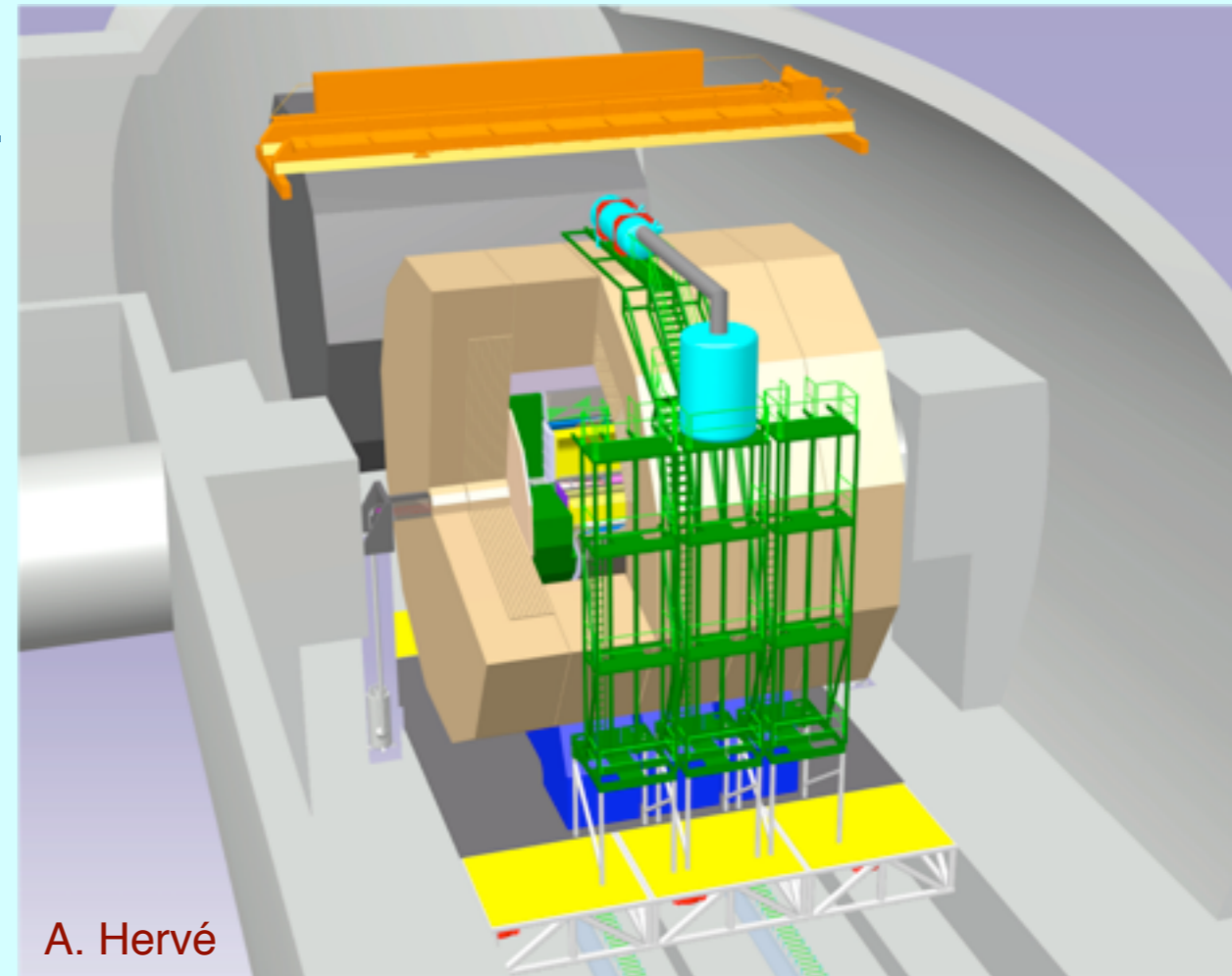
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Detector Motion System

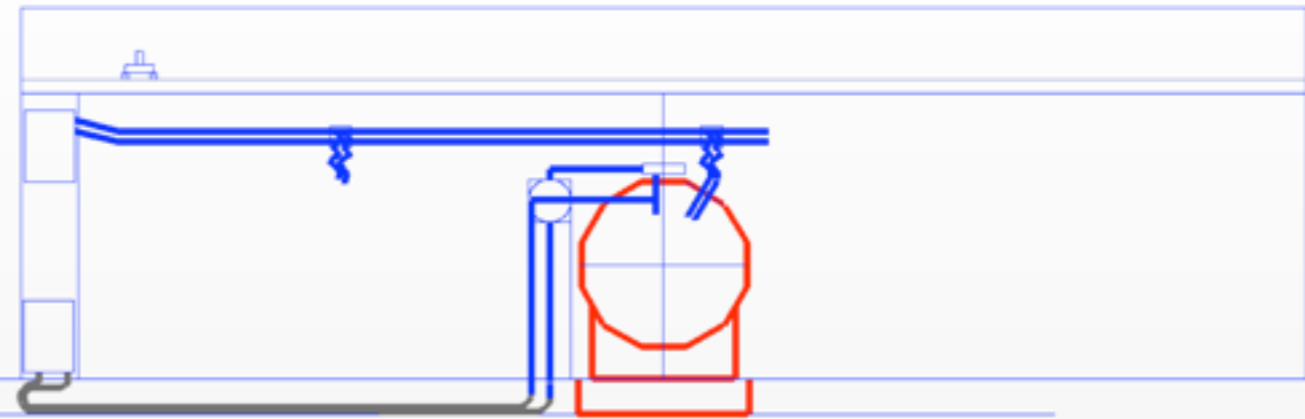
ILD Push-pull Concept

ILD prefers platform based design:

- All services would be run through cable-chains (including cryogenics)
- Main bus-bar for voltage supply to the detector solenoid
- Aim: two days for the push- or pull-operation
 - one day for the mechanical movement
 - one day for calibration
 - after significant learning curve experience

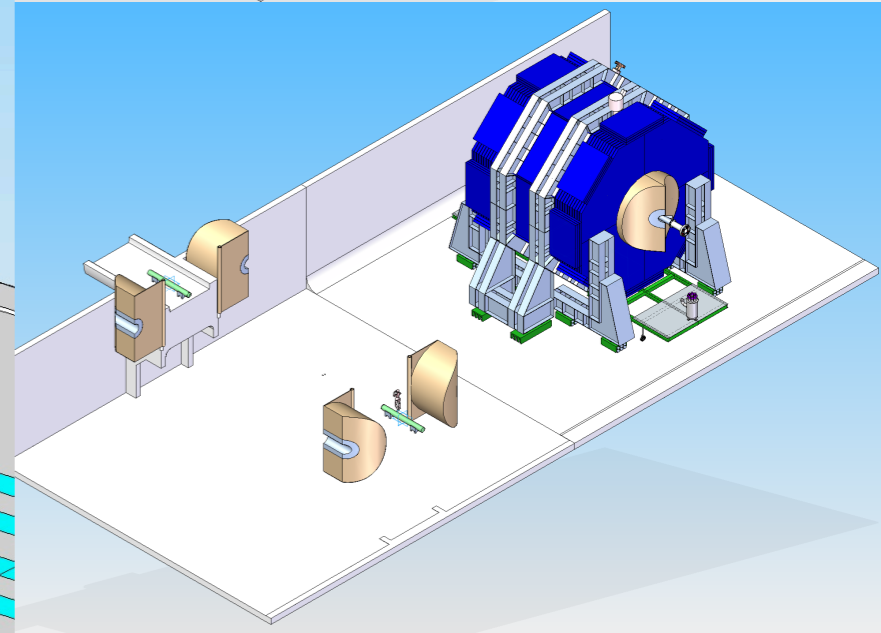
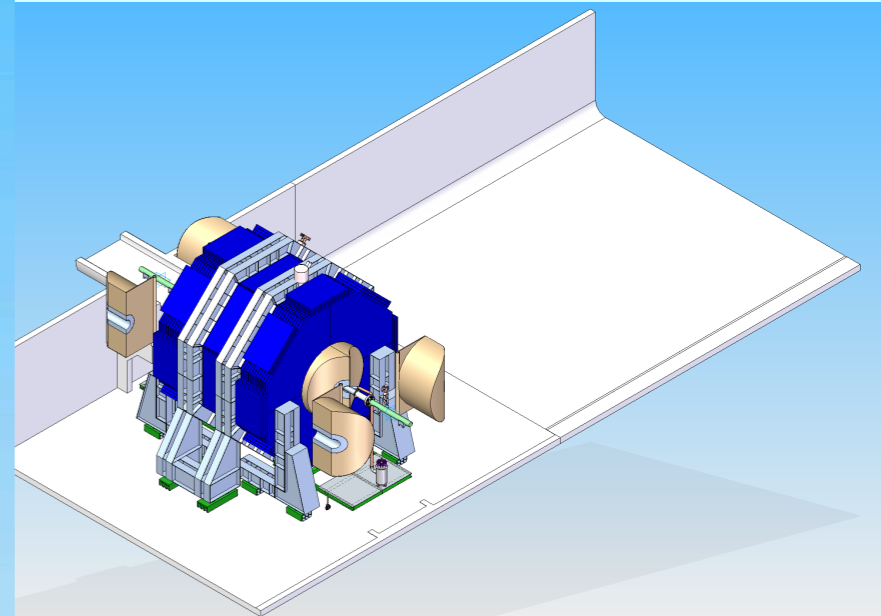
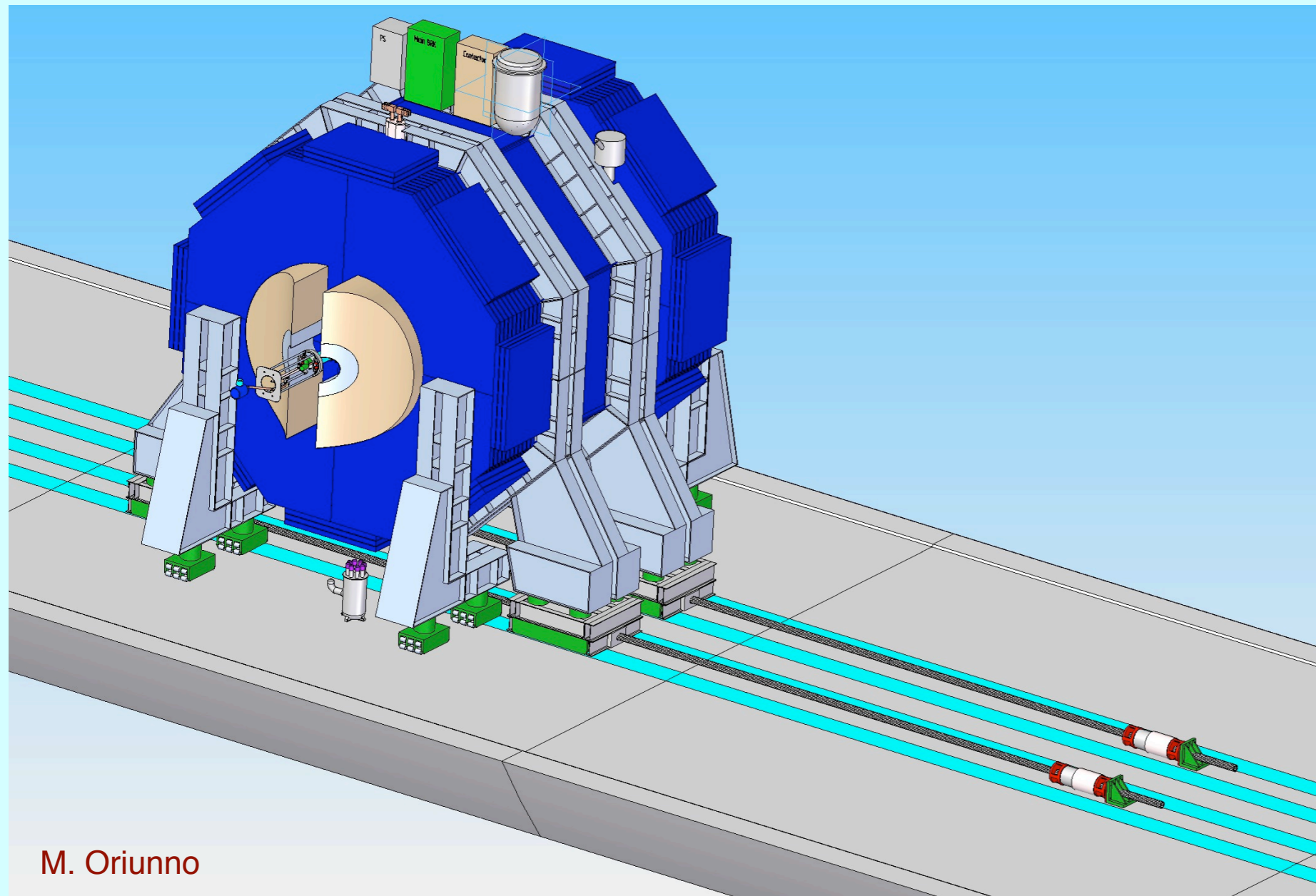


A. Gaddi



SiD Push-Pull Concept

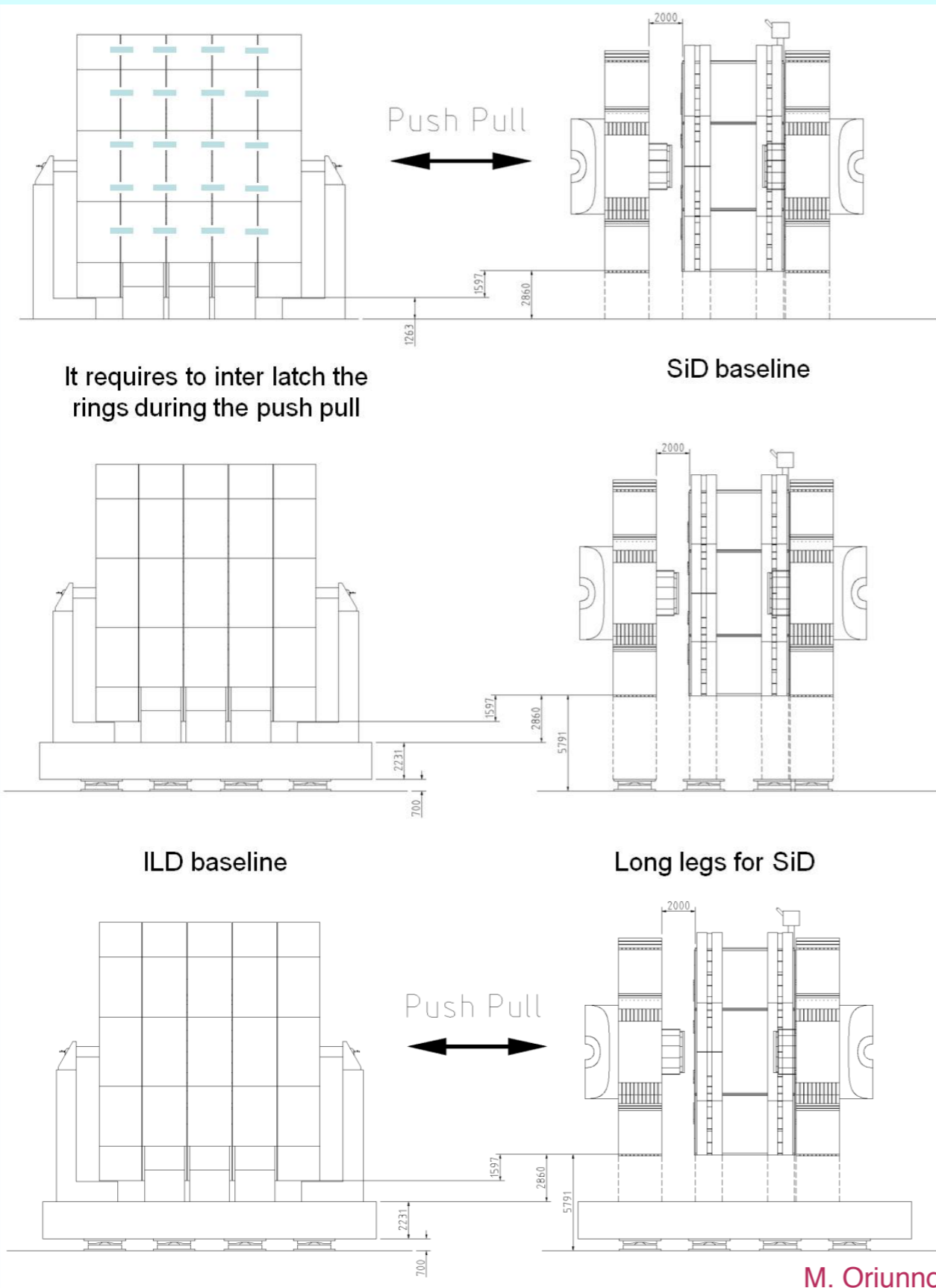
- SiD wants to run on hardened steel rails using Hilman rollers
- Time needed ~ 1 day for luminosity-luminosity transition
 - learning curve effects will be involved....



- Option 1: ILD and SiD moving on the floor

- Option 2: ILD on a platform, SiD moving on the floor

- Option 3: ILD and SiD on platforms
 - could have different heights



M. Oriunno

Pros and Cons of a Platform

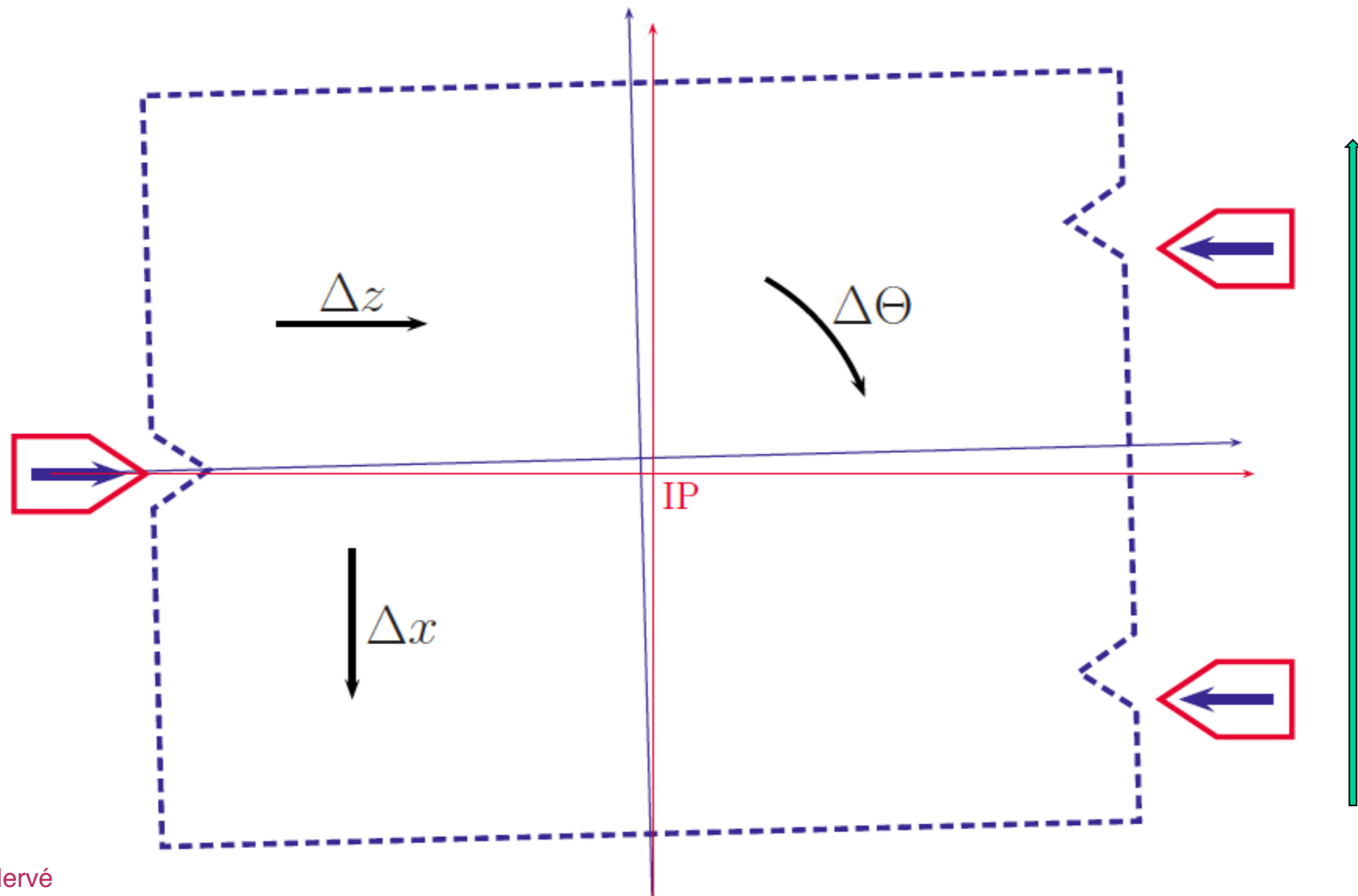
PROS

- Decouples detector support from ground floor behaviour
- Separates push-pull moving system from detector
- Reduces vibrations during detector movement
- Keep inter-alignment of detector parts
- Movement directions are decoupled
- Possible earth-quake damping system
- ILD design depends on it (yet)
- Potentially less expensive
 - if ground preparations for non-platform system are difficult

CONS

- Adds additional complicated system to a challenging task
- Easier access to detector motion system
- Proper floor preparation and proper designed rail based motion system might be easier to realise
- Platform is an additional source or amplifier for vibrations
- Potentially more expensive
 - cost for platform

With Airpads a simple positive indexing mechanism is possible giving $\approx \text{mm}$ precision 



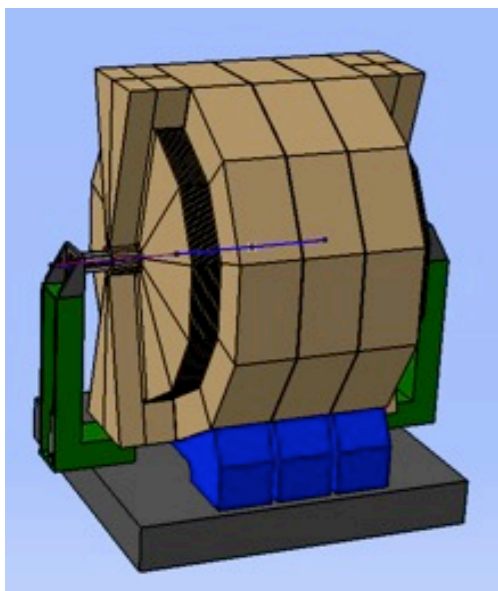
A. Hervé

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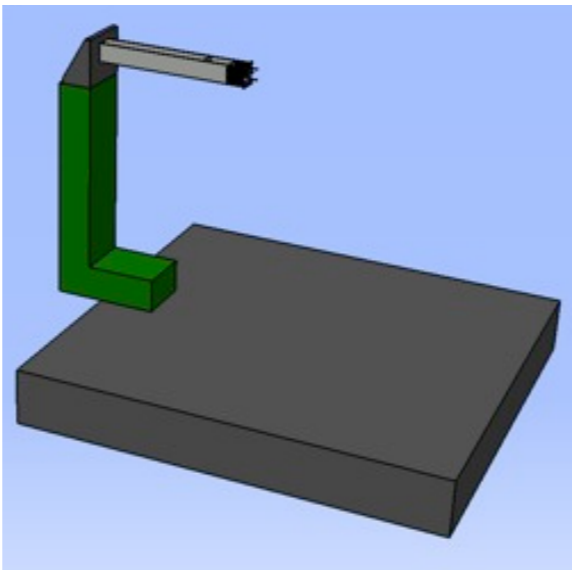
QD0 Supports



ILD00 model

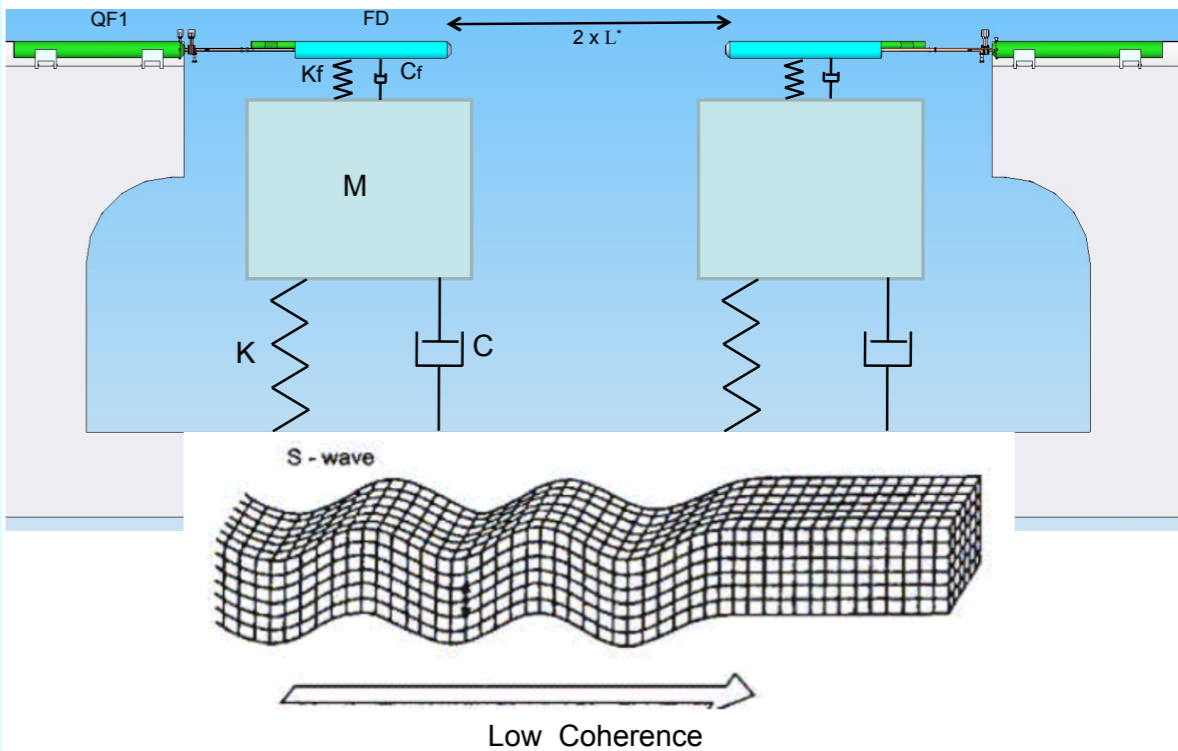


ILD QD0 support system



M. Joré

Independent Supports (Cavern,Pillars Platform)

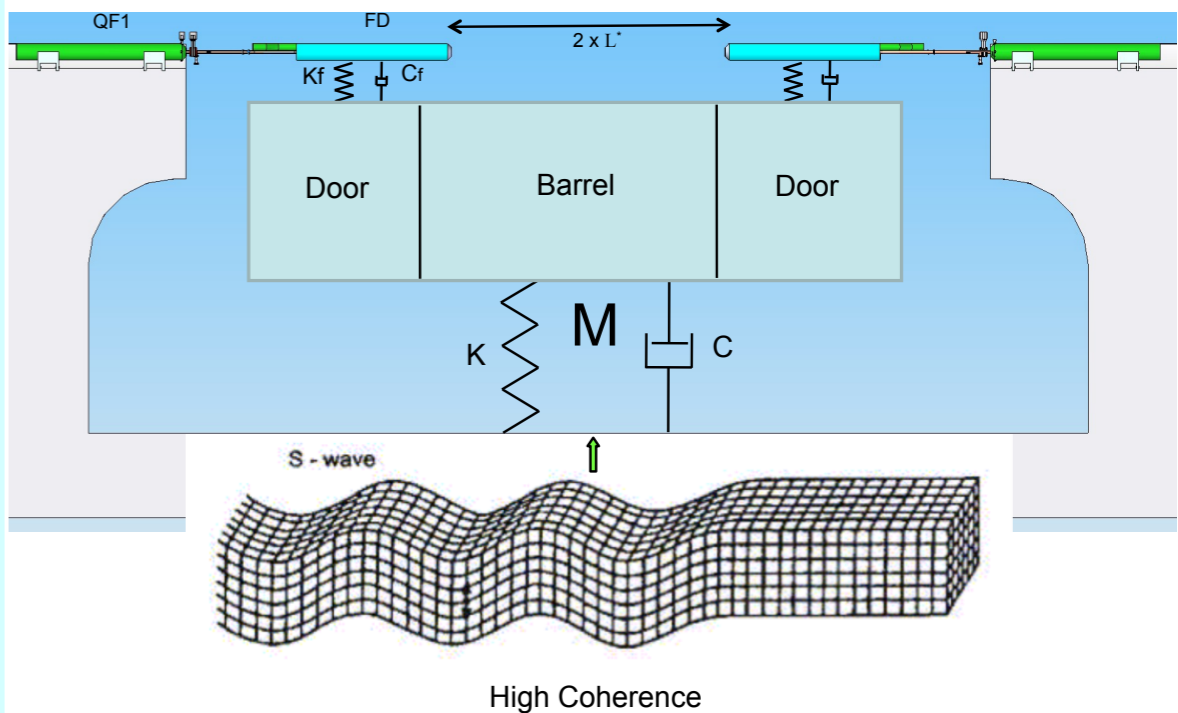


M.Oriunno, IWLC10 – Geneva, Oct.2010

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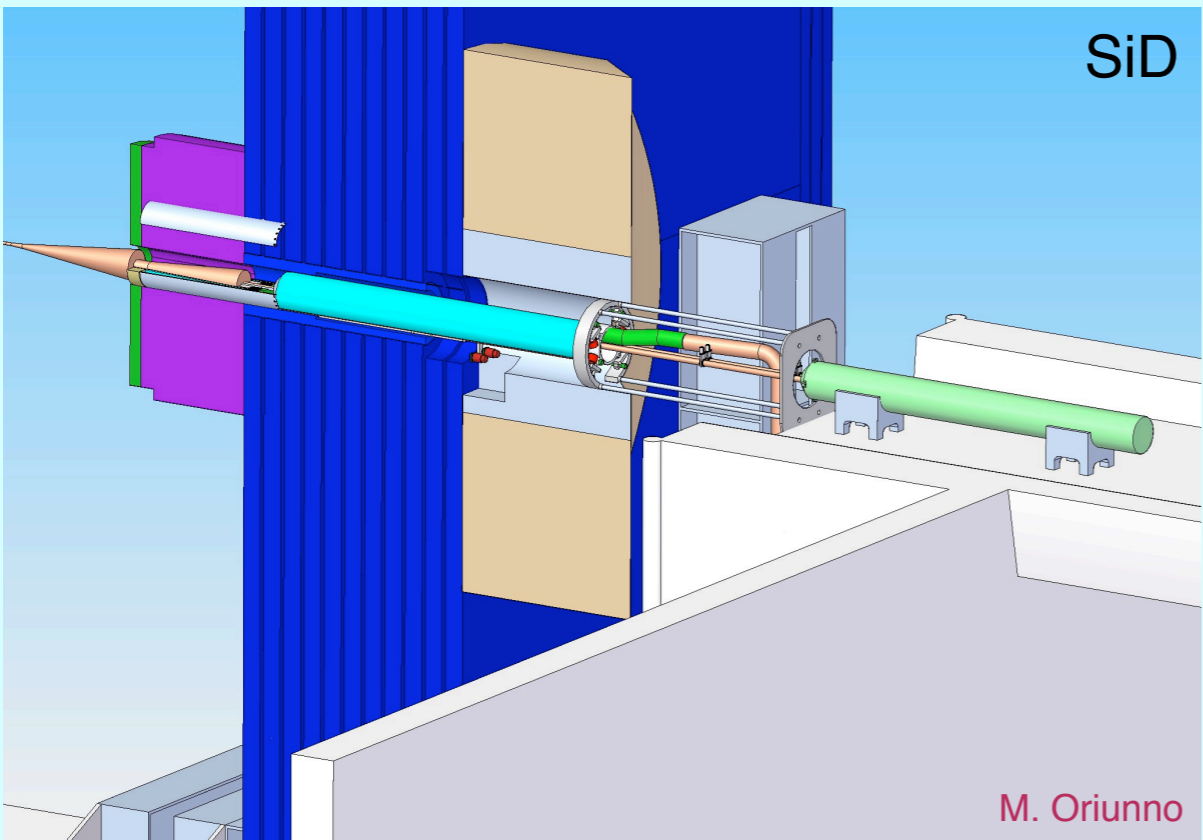
Common Supports (Detector under mag.field)

M. Oriunno



M.Oriunno, IWLC10 – Geneva, Oct.2010

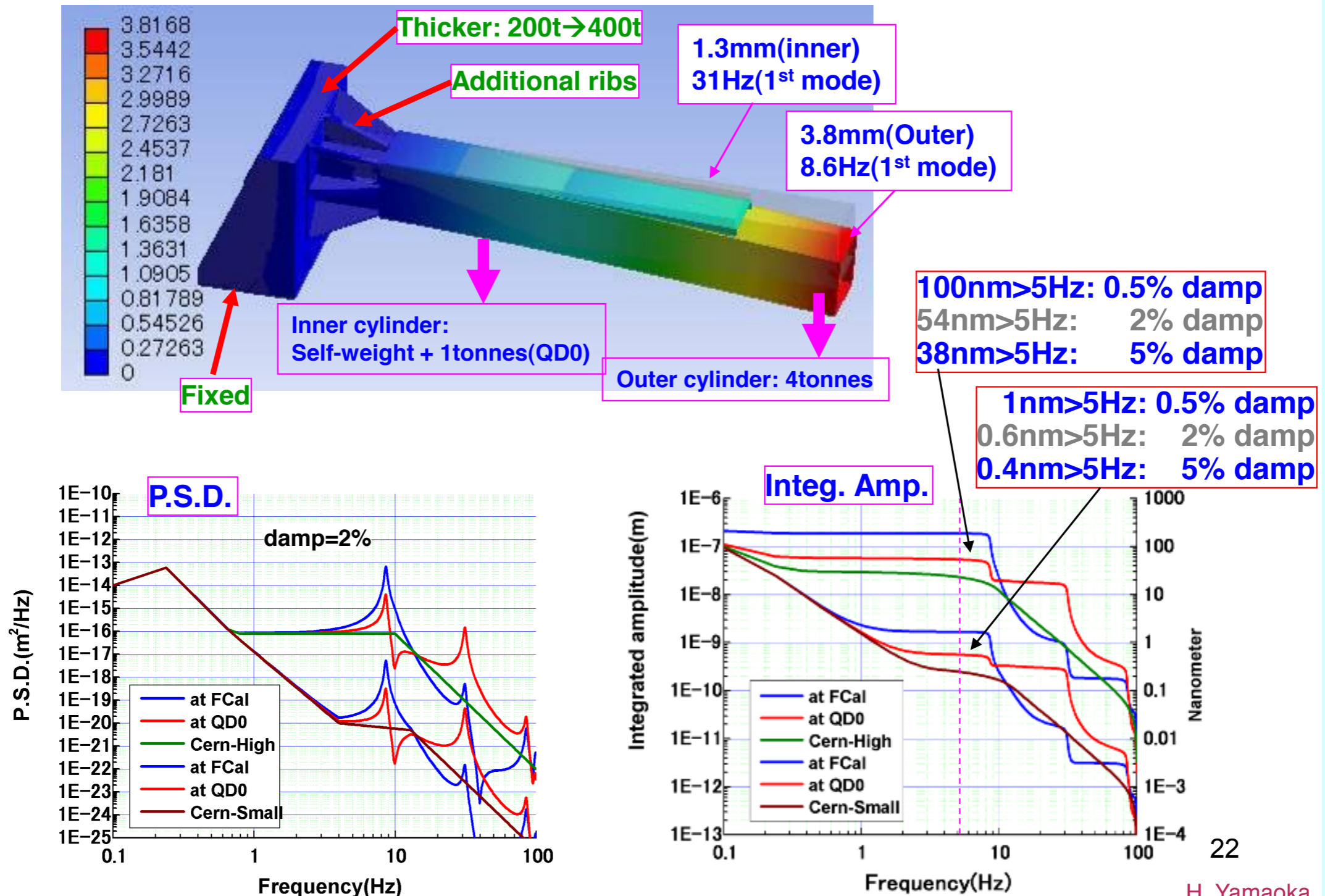
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M. Oriunno

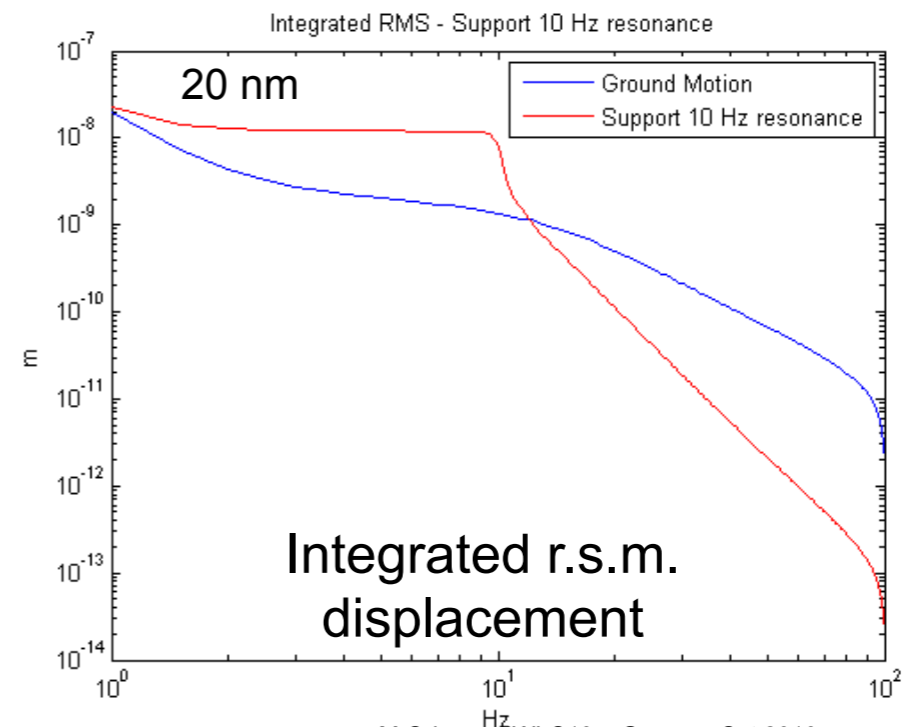
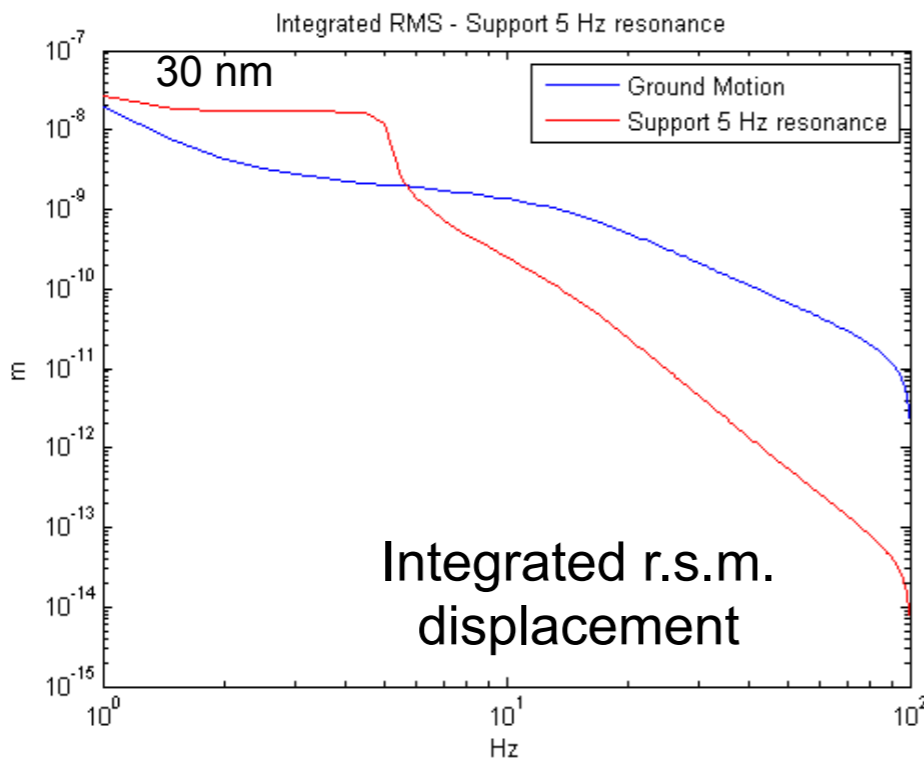
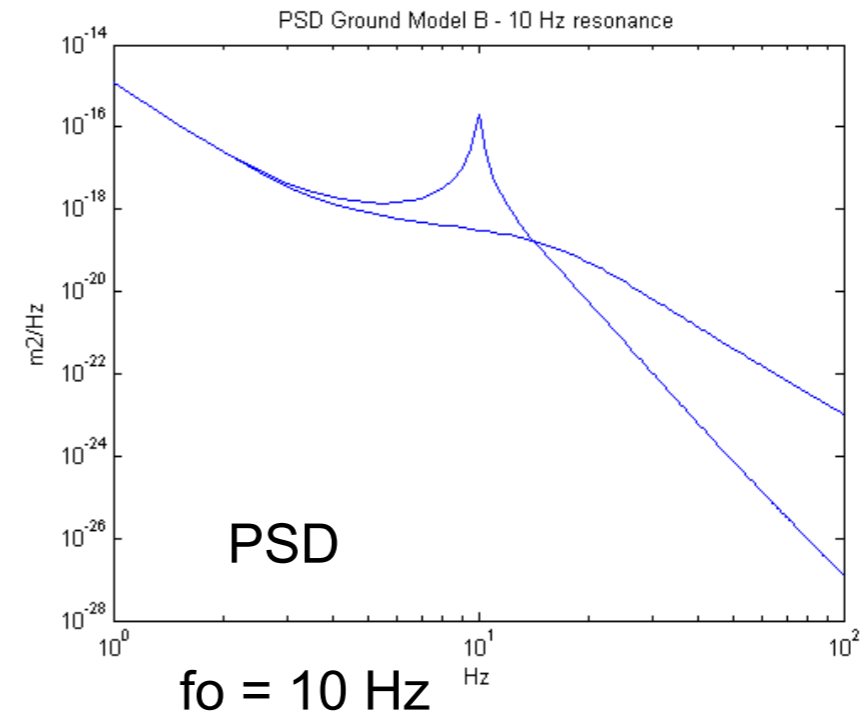
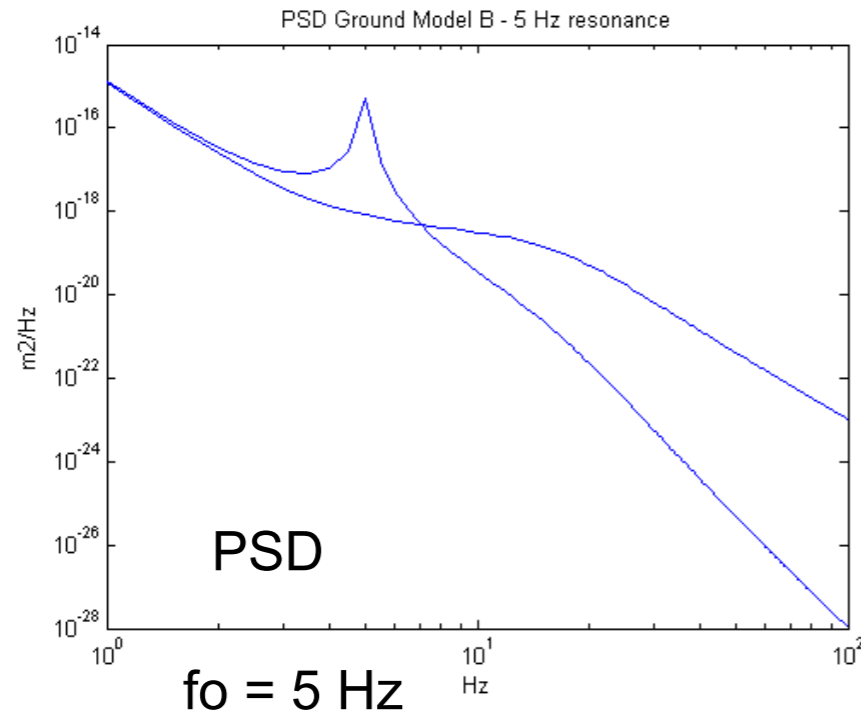
Calculation(Presented at Beijing meeting)

Respond amplitude at each position is estimated.



H. Yamaoka

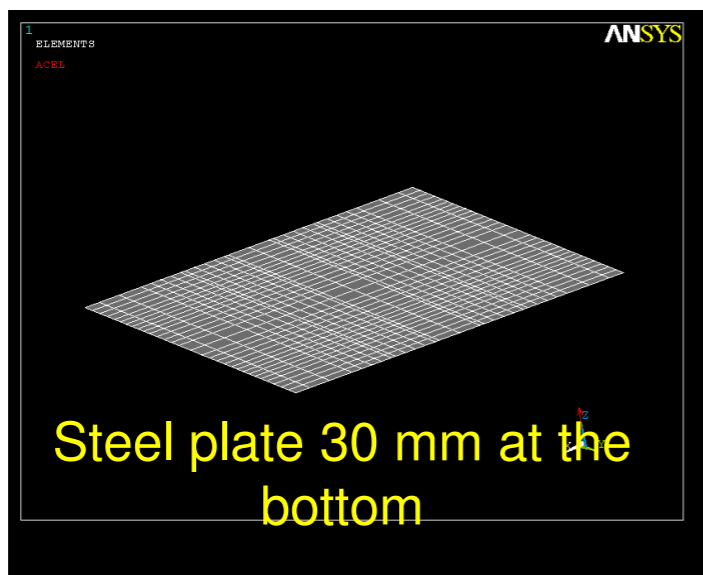
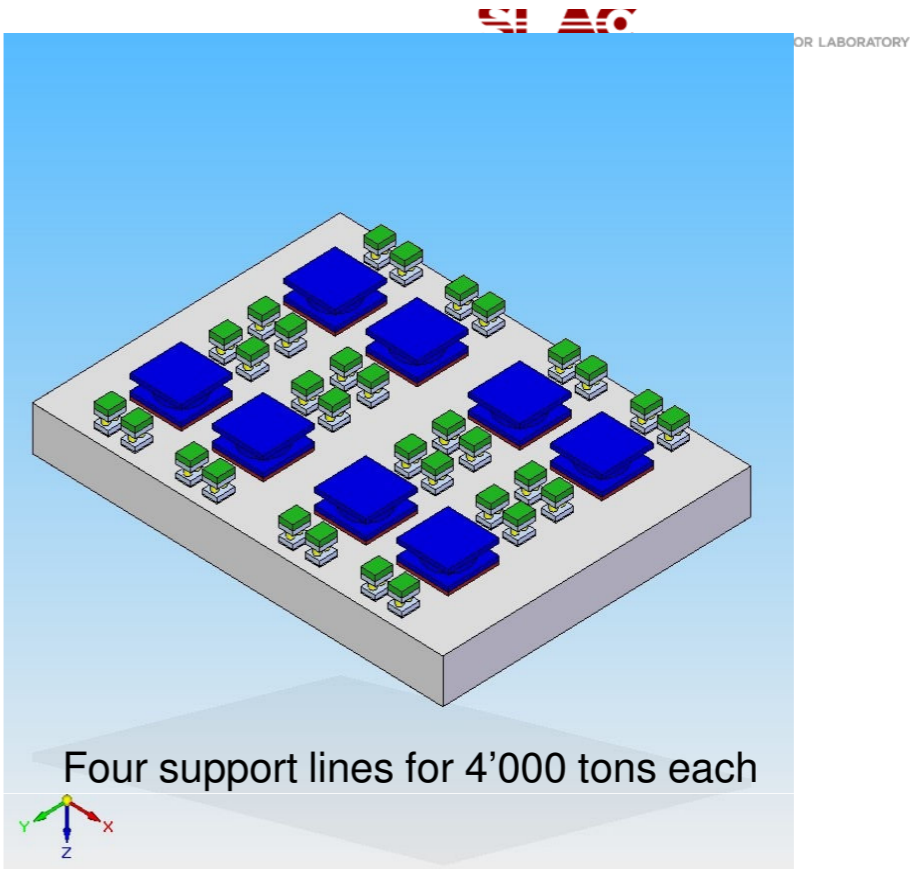
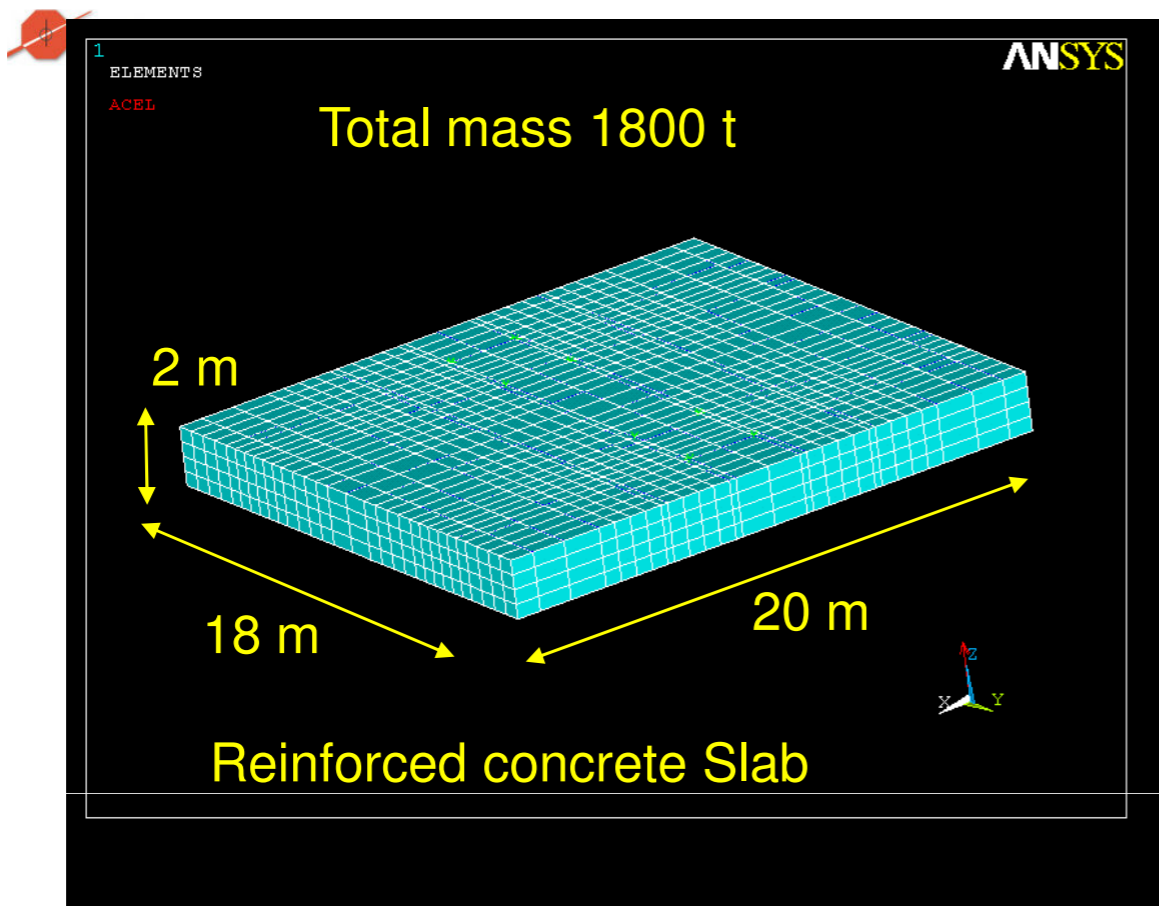
Random vibration Studies : SiD O.K. on the floor, no platform



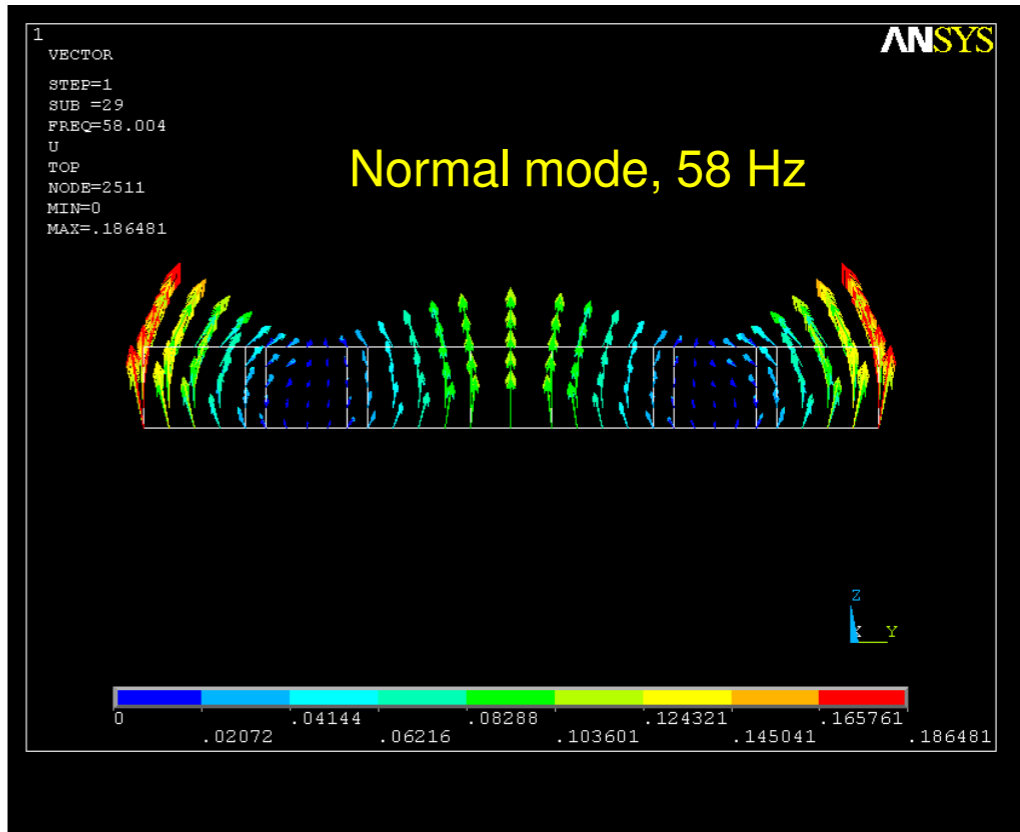
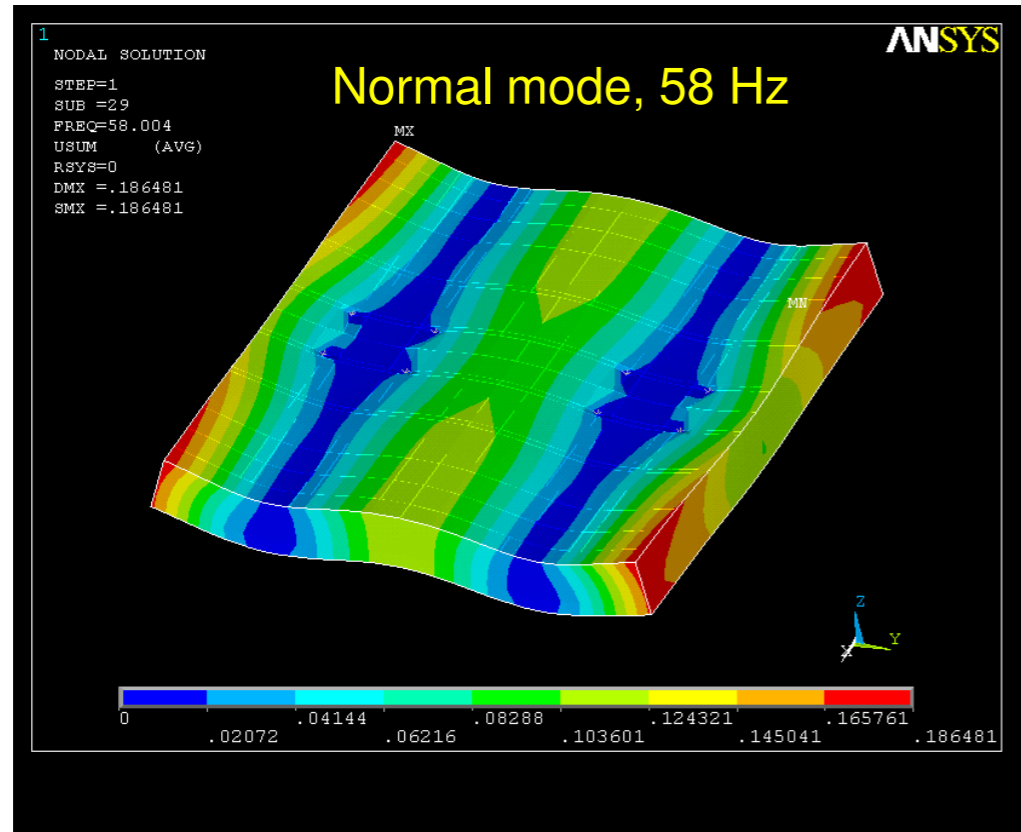
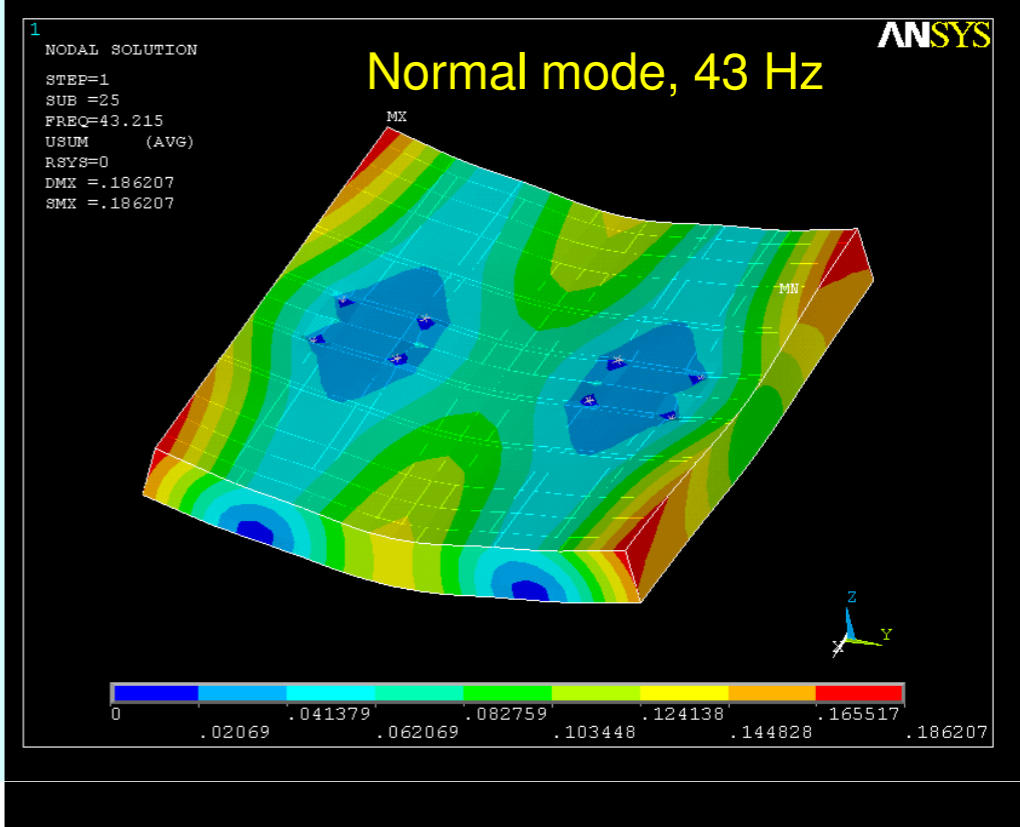
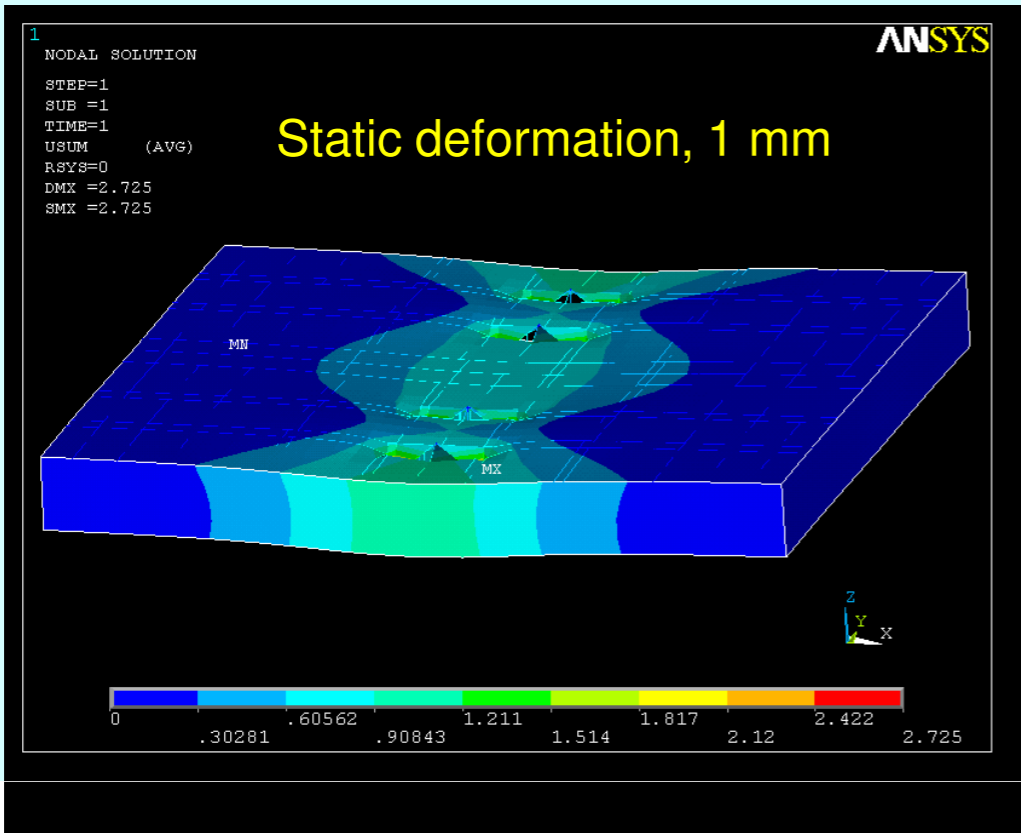
M. Oriunno

M. Oriunno, 1WLC10 – Geneva, Oct. 2010

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M. Oriunno





Steel reinforcement of CMS Plug \Rightarrow
Models need benchmarking



to evaluate damping and Young's modulus

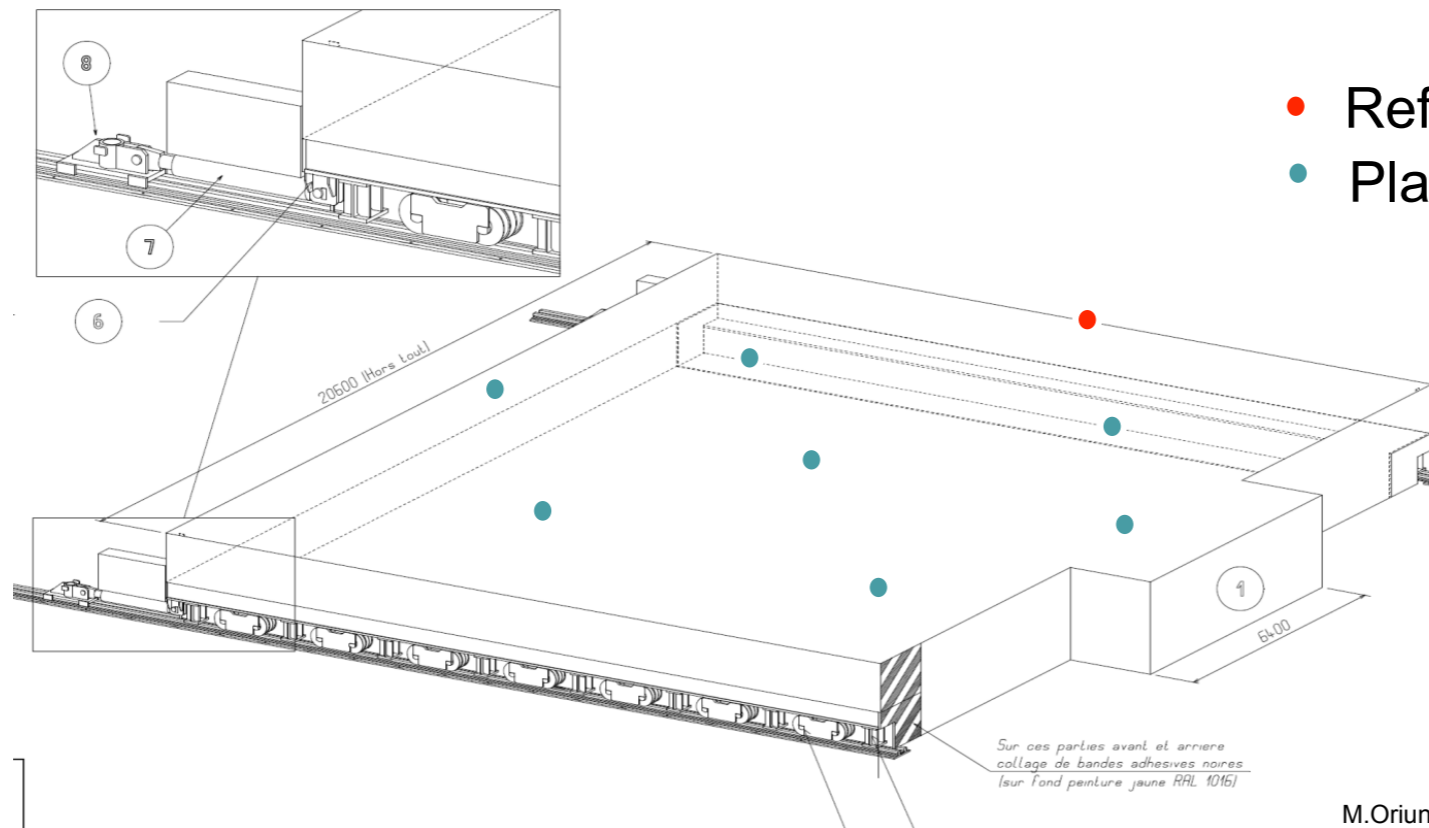


A. Hervé

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New Vibrations Measurements done at CERN last week, Analysis of the data in progress (CERN-EN Department)

- Absolute PSD spectra on various locations on the top of the platform, P1...P7, with the reference points PREF1, PREF2
- Relative PSD spectra, P12, P17 (Coherence) (can be calculated from the previous measurements)
- Transfer functions on various locations on the top of the platform P1-2-3-4-5 with respect to the reference points
- Transfer Functions P1...P7 with reference to the ground vibration



- Reference geophones
- Platform geophones

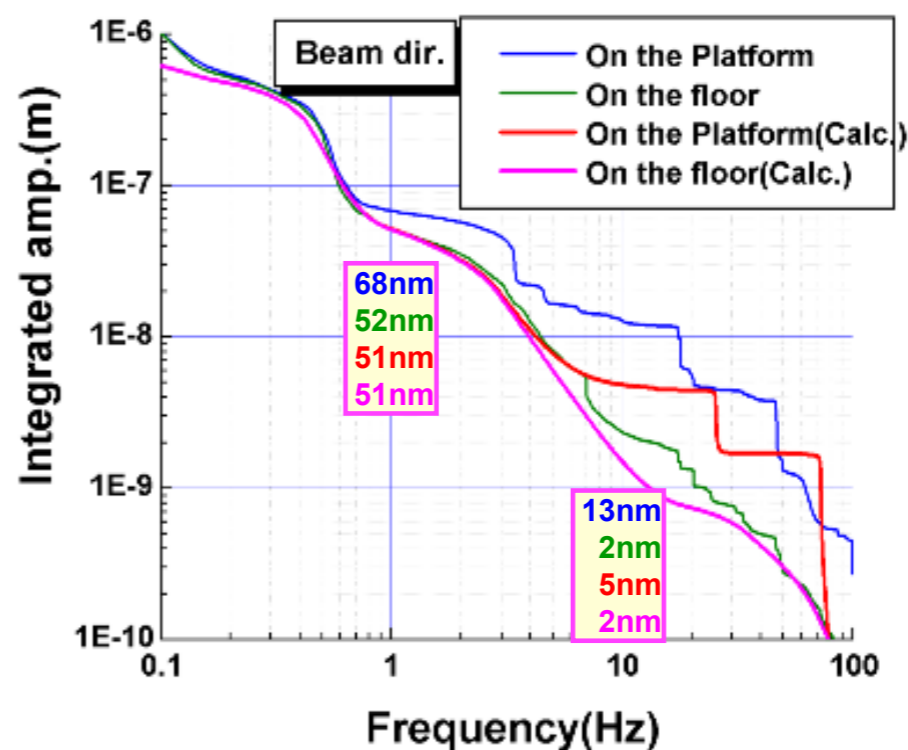
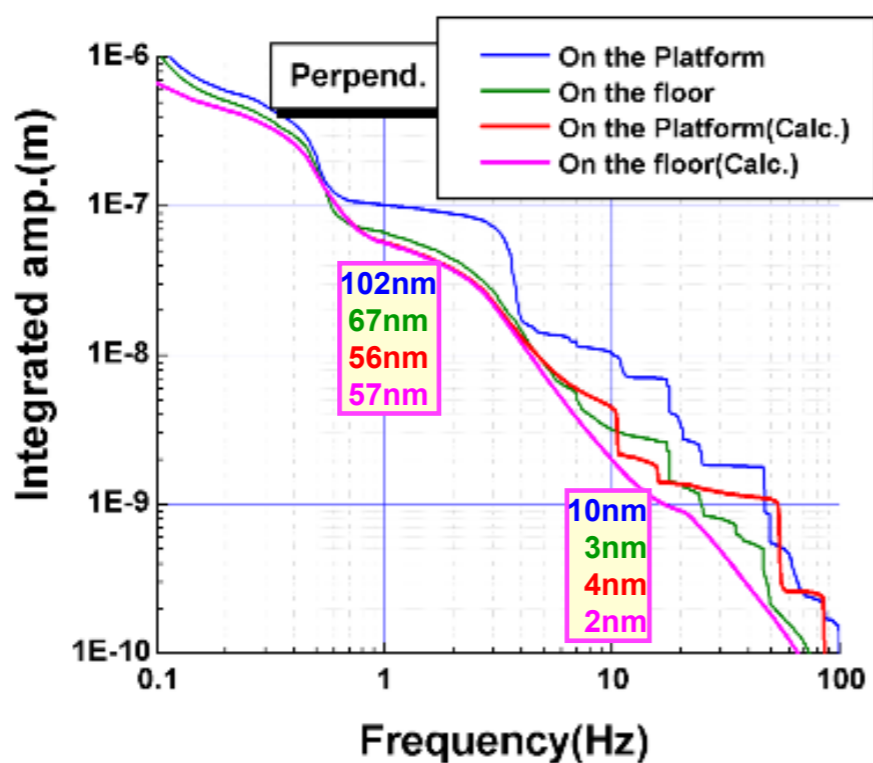
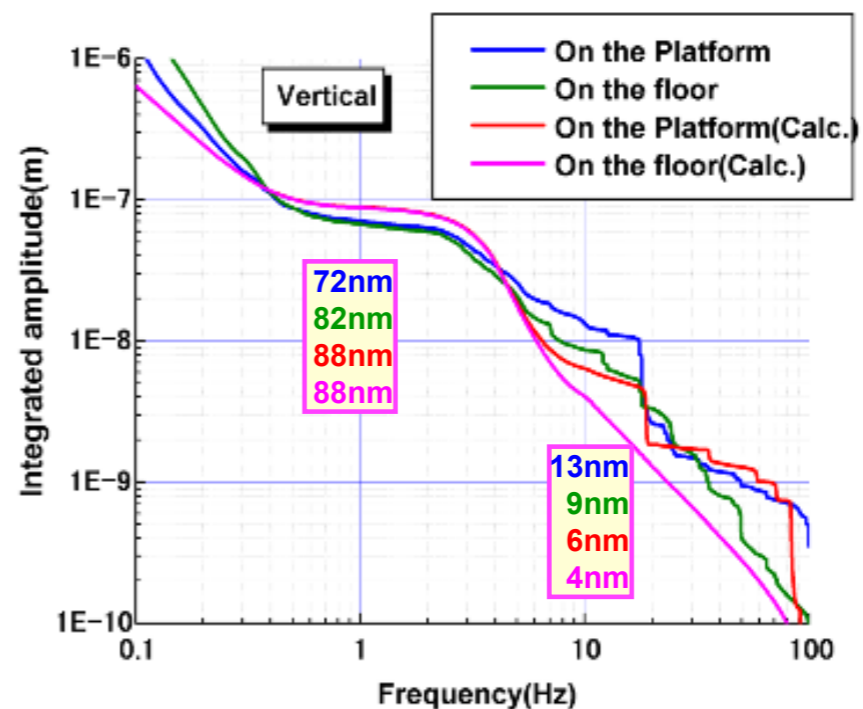
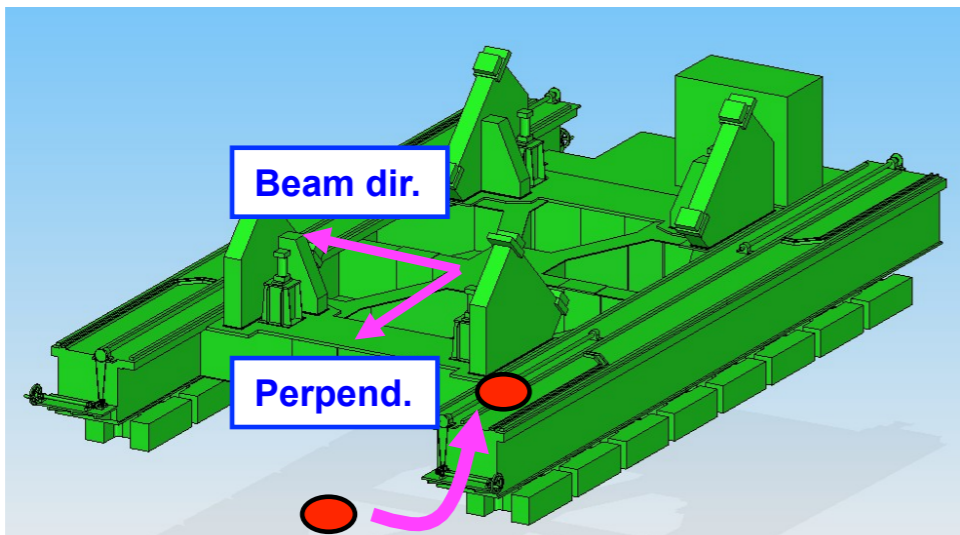
Data taken at
CERN in October

M. Oriunno

M.Oriunno, IWLC10 – Geneva, Oct.2010

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Vibrations(Amplitude)



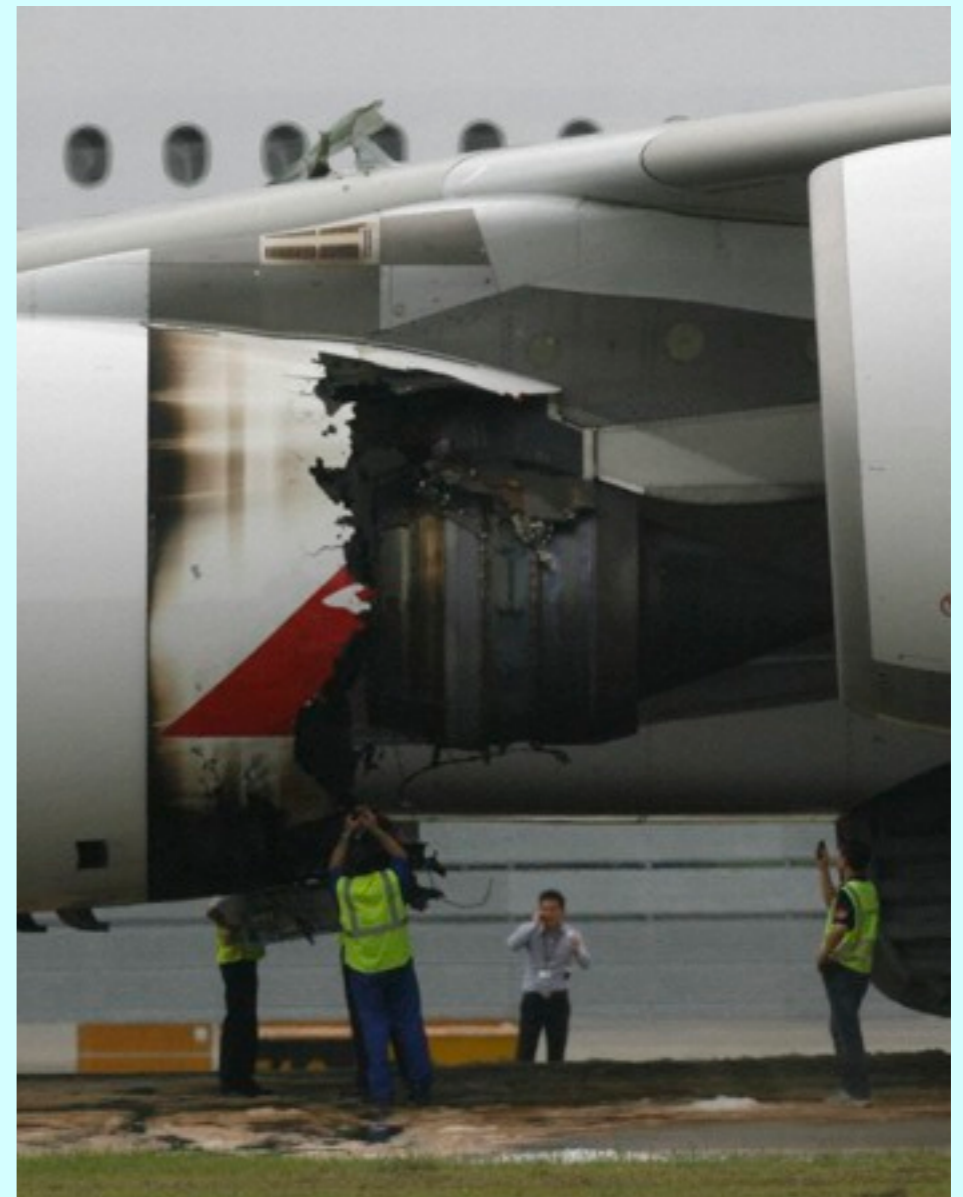
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H. Yamaoka



The detector motion system must never fail!

- Any failure of the system has the potential to shut down ILC operations for very (!) long times
- The system must be designed for repeated reliable and safe operations
- This needs to be studied carefully:



Moving Heavy Devices is Difficult!



Moving Heavy Devices is Difficult!



Moving Heavy Devices is Difficult!



Detector Motion System Decision Process

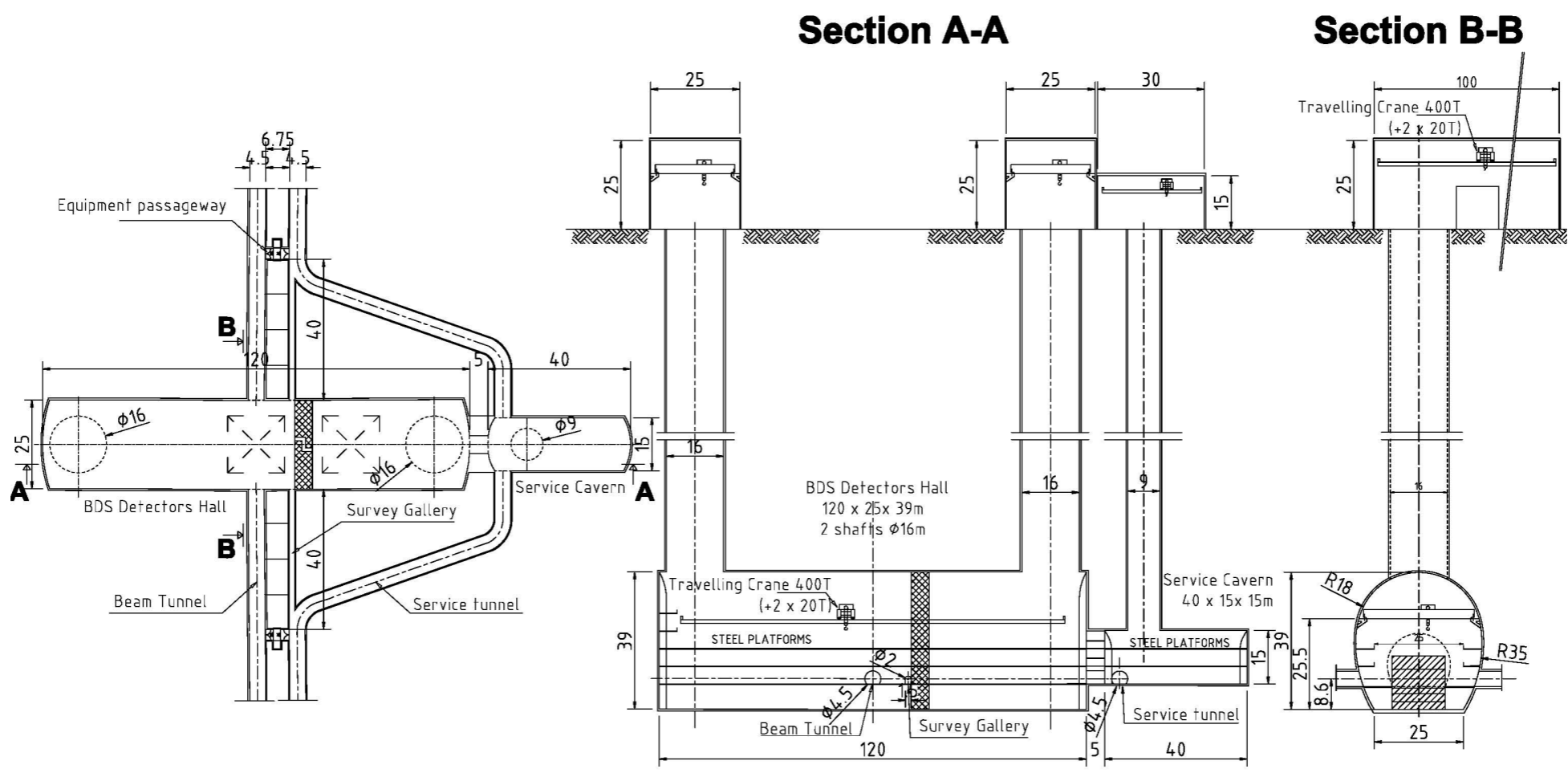
- Either both detectors will be on a platform or no platform at all
- ILD detector design - integration and assembly procedures - is interwoven with the platform concept
- SiD prefers a possibly simpler rail based system
- Most important topics:
 - Vibration analysis:
 - Benchmarked FEM calculations of the full system:
 - Ground → Motion System → QD0 Support → Magnets
 - Risk analysis
 - Design changes to existing concepts
 - Cost
- Decision needs to be taken in 2011
 - Design changes to the detectors need to be done
 - DBD/TDR is due in 2012
- Envisage decision by the time of the Oregon workshop: 03/2011

Civil Facilities and Underground Hall Design

Detector Assembly and Integration



Plan and Sections (Europe)



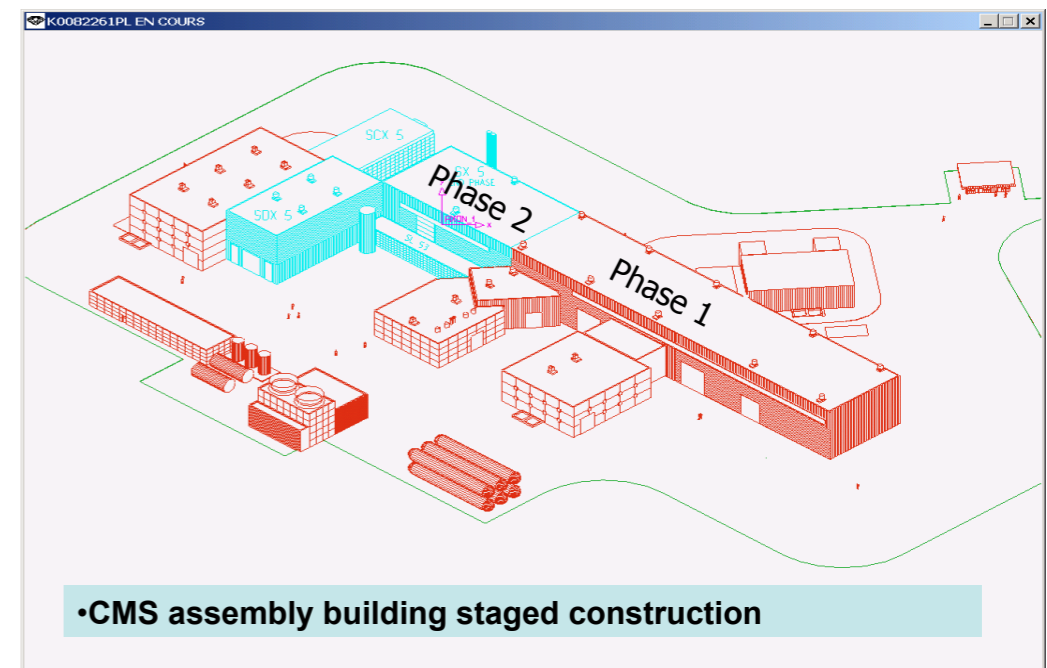
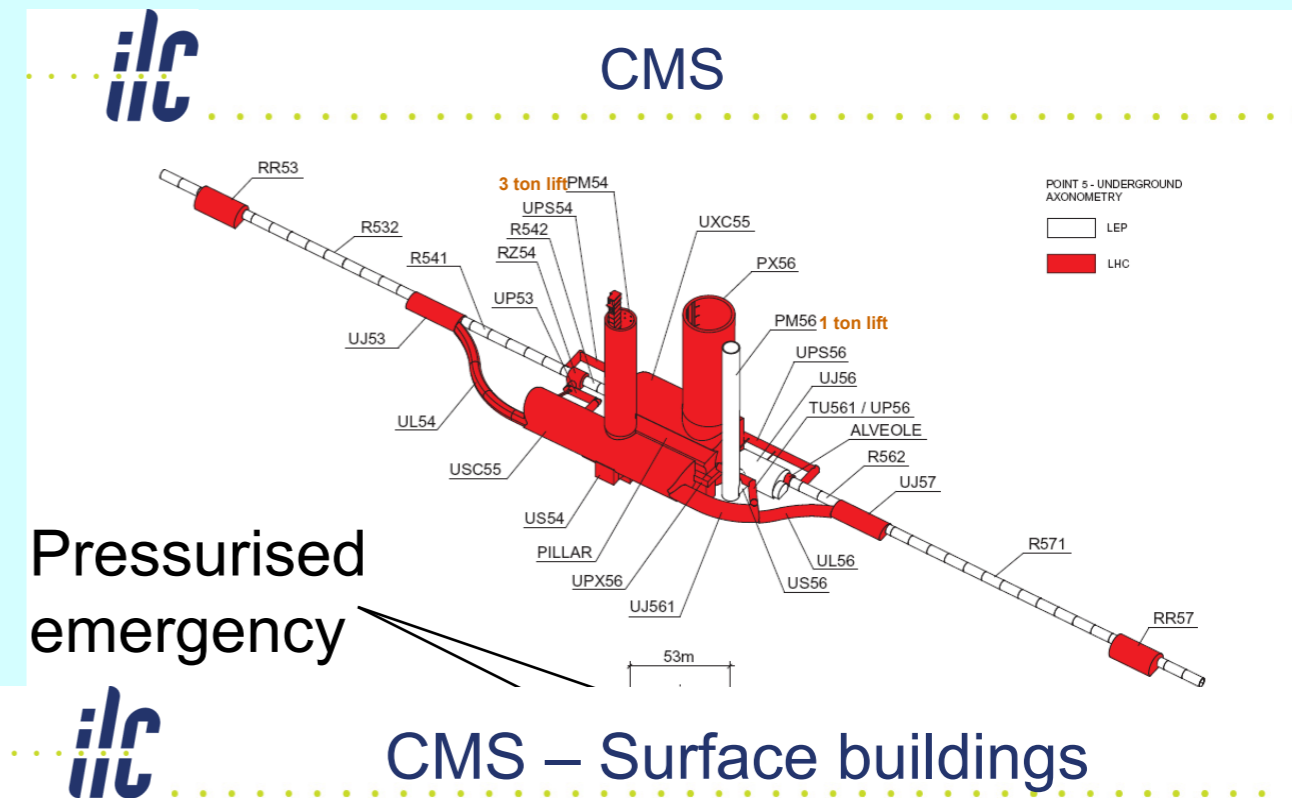
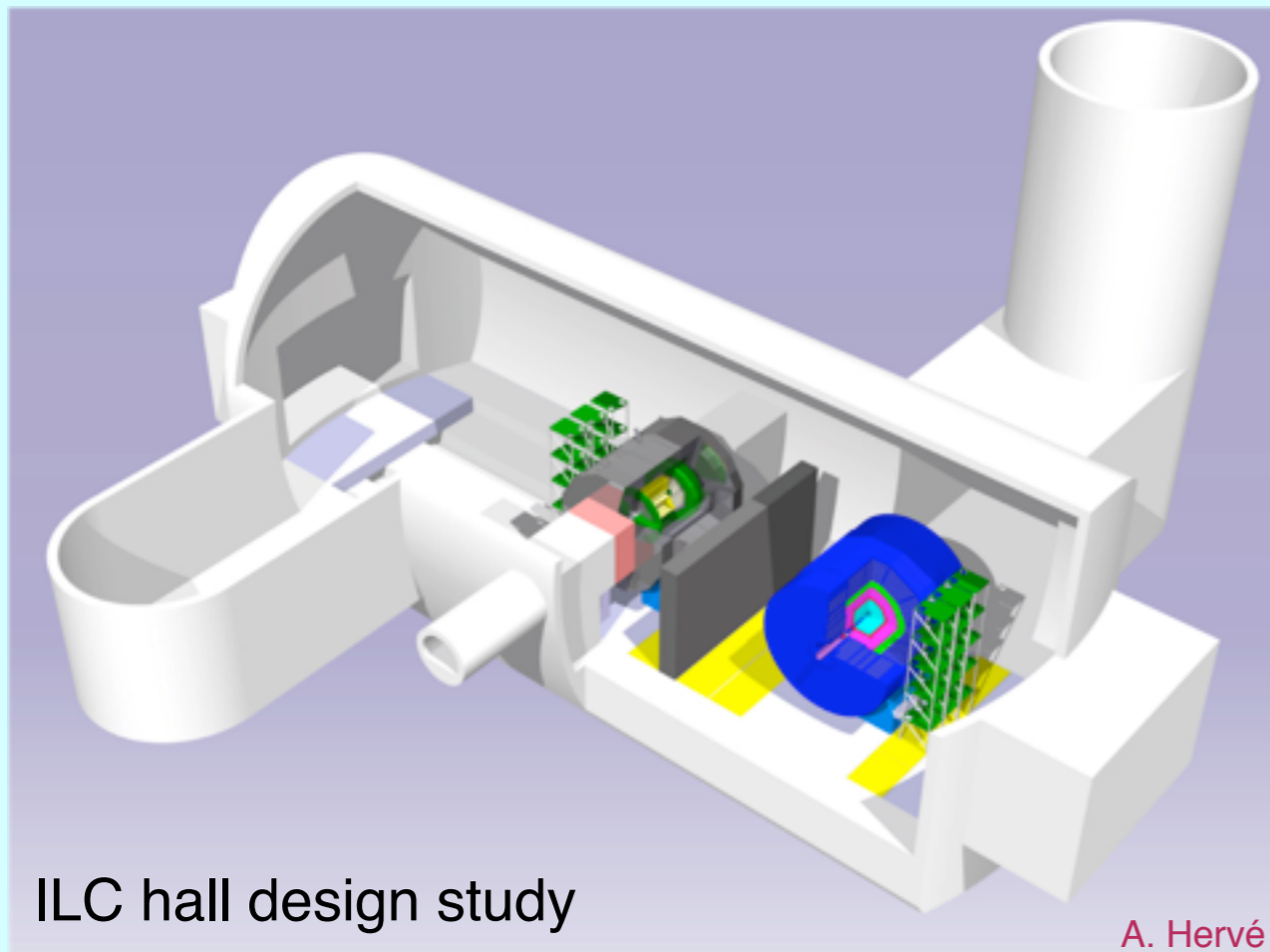
Date Event

Global Design Effort

7
T. Lackowski

For Comparison: CMS

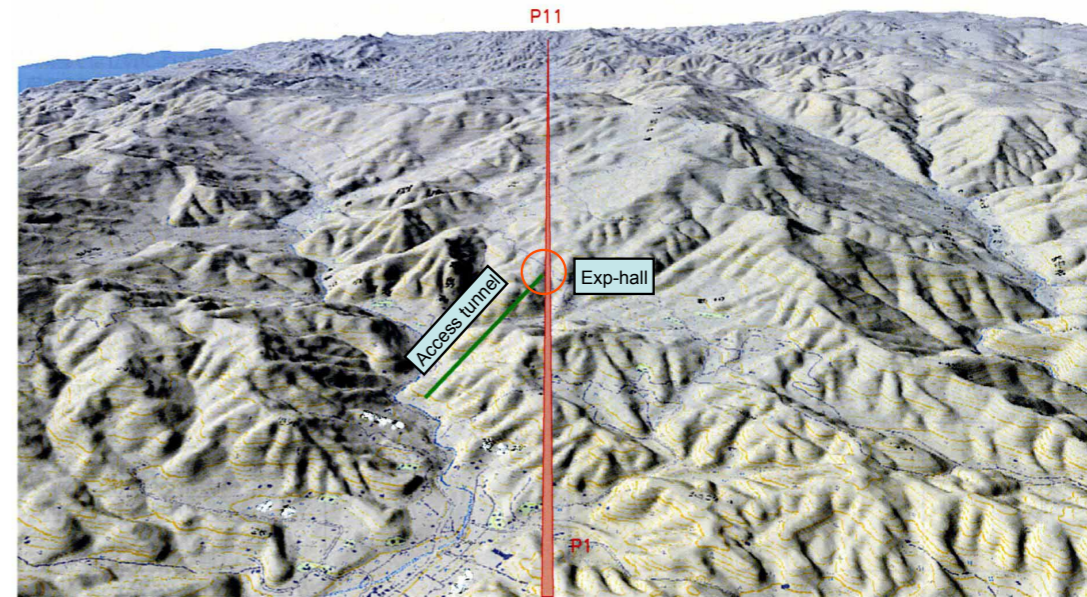
- RDR Design needs to be elaborated w.r.t. the real needs of the experiments:
 - Optimisation of underground space
 - Detector services needs
- Close collaboration with CFS group planned



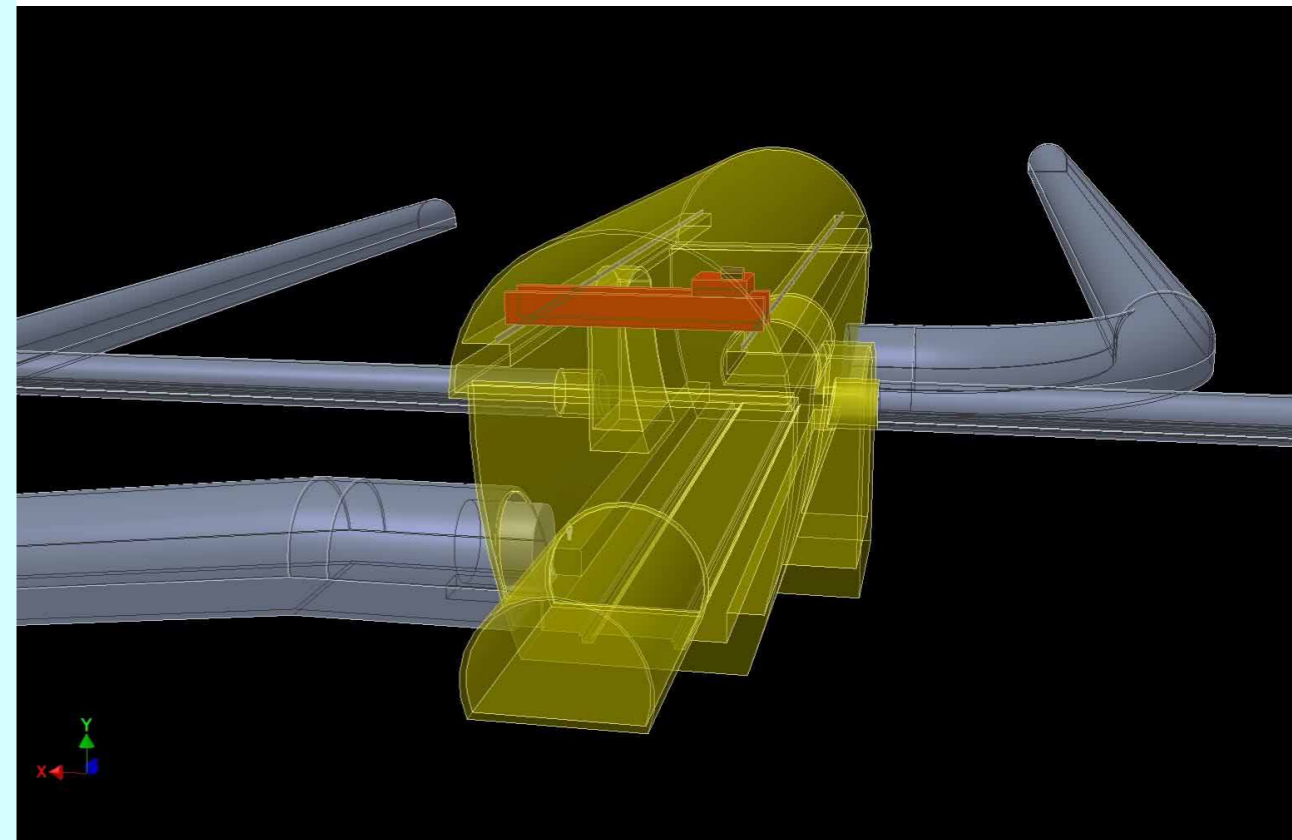
T. Lackowski

- Mountainous sites might change the CFS requirements significantly:
 - No vertical access shafts $O(100\text{ m})$
 - Horizontal access tunnels $O(1\text{ km})$ with smaller diameter
- Has impact on transportation of detector parts
 - Assembly procedures might be different
 - Surface assembly à la CMS not possible
 - Coupling of schedules between detector and machine construction need to be studied in detail

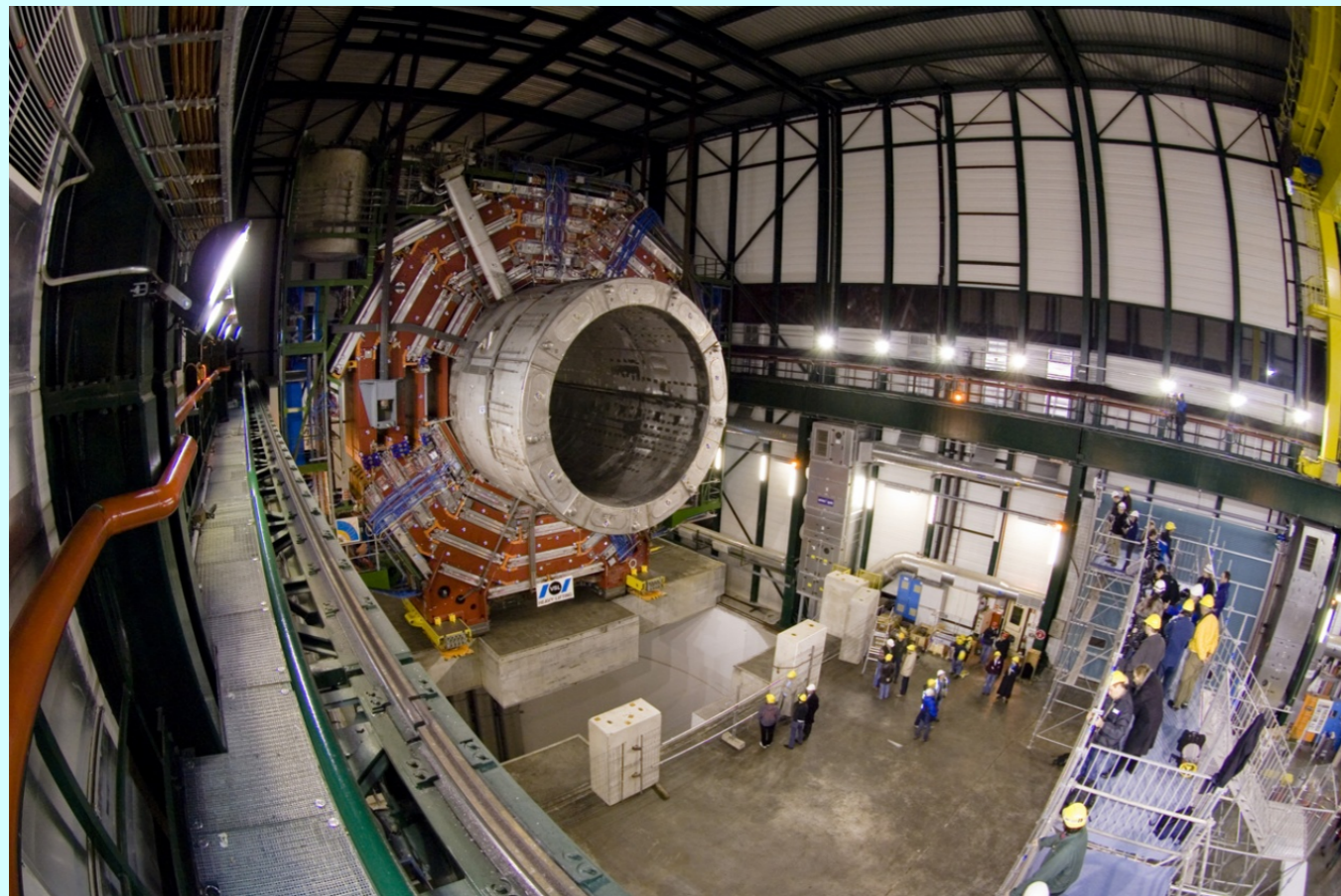
An example of Asian mountain site



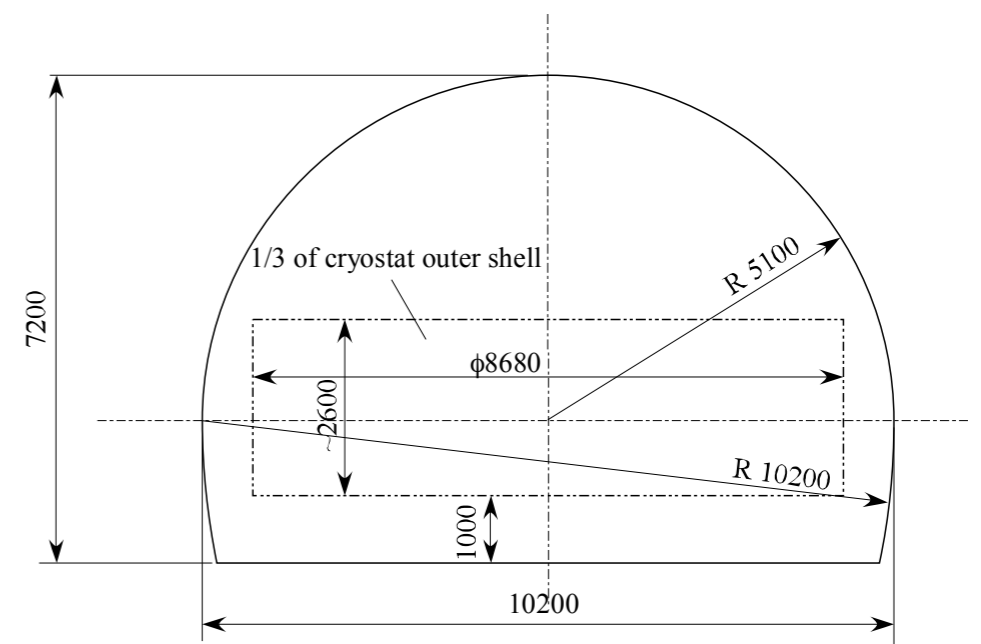
Y. Sugimoto



- RDR baseline:
 - Surface assembly of major detector parts
 - Lowering of big parts into the hall
 - Relatively short underground assembly and commissioning time needed
- If horizontal access tunnels:
 - Pre-assembly in smaller parts (e.g. maybe coil cannot be delivered in one piece)
 - Optimisation of underground assembly procedure (space and time) needed



Access tunnel



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Y. Sugimoto

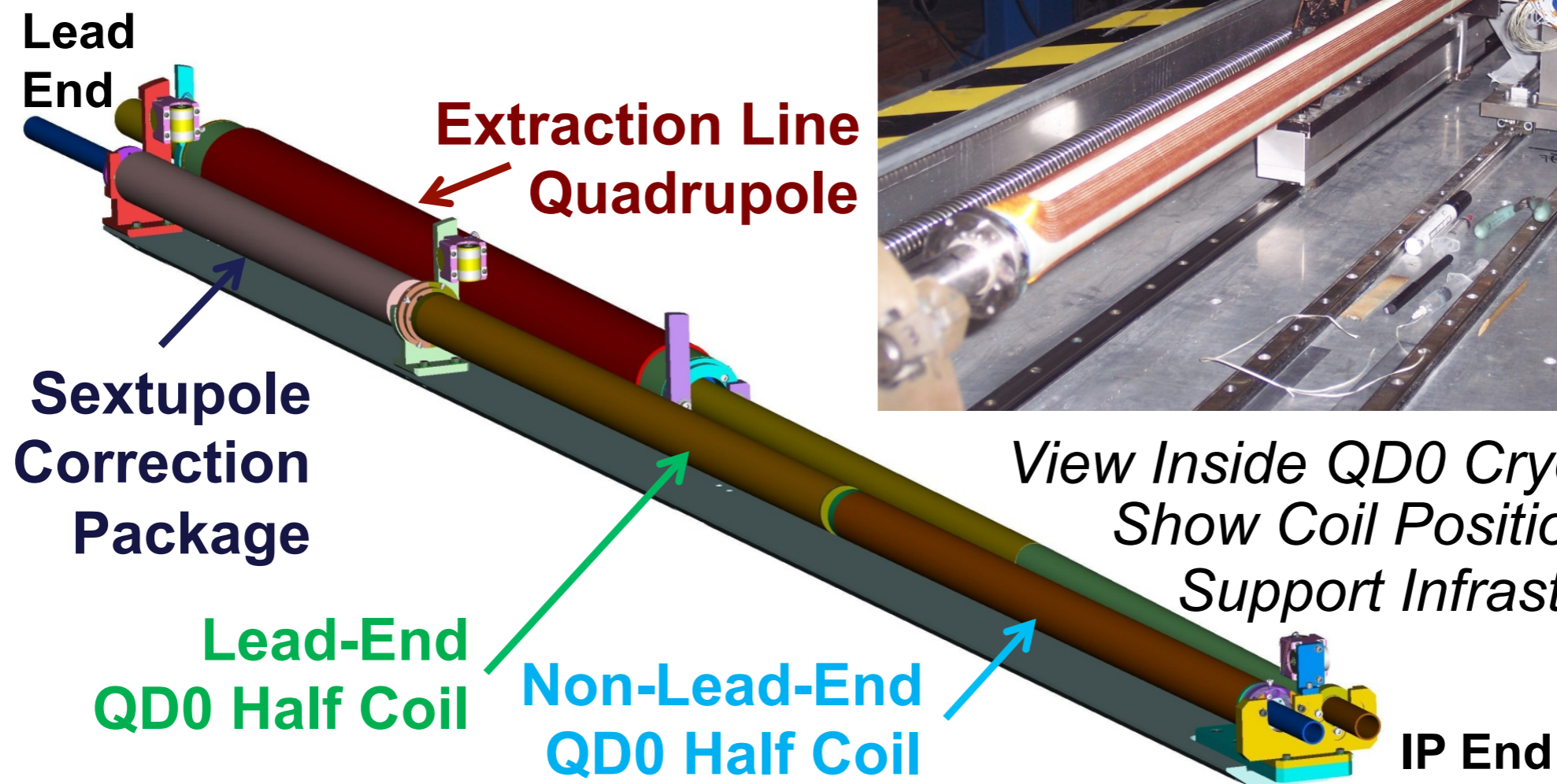
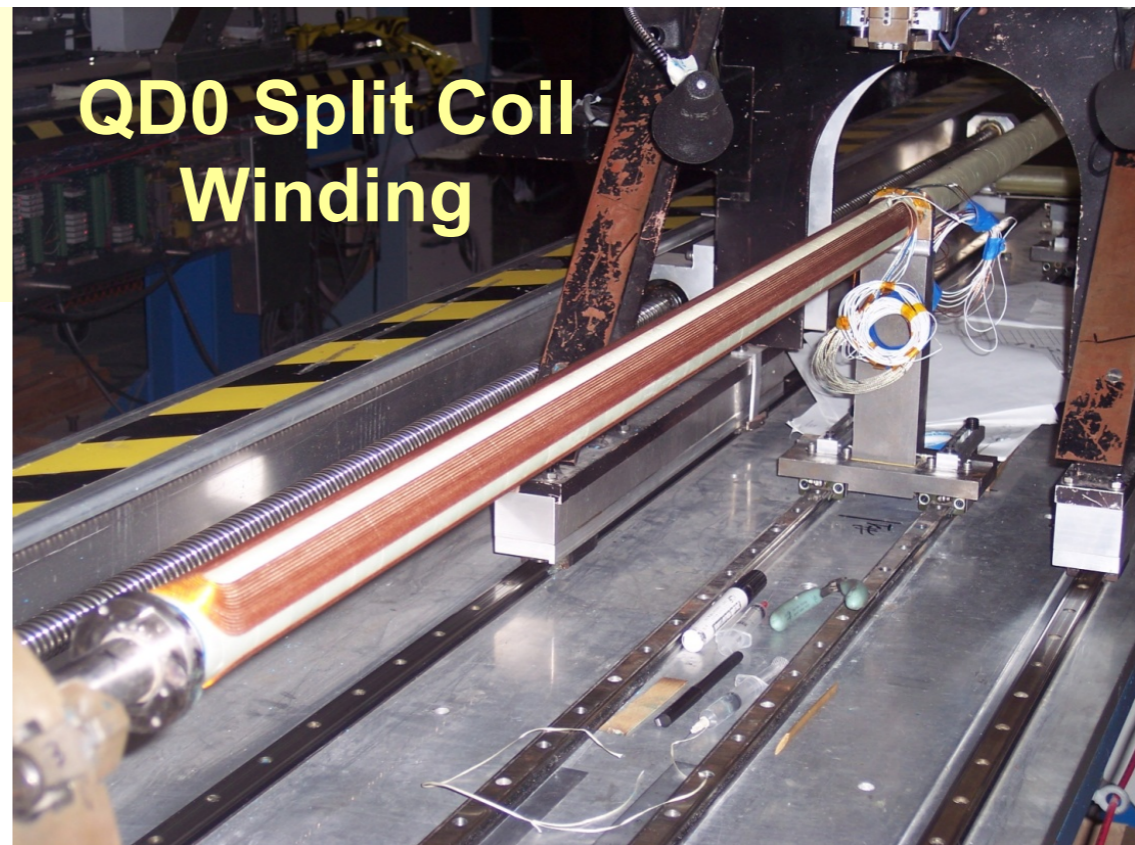
Final Doublet Magnet Developments

Alignment System Developments



QD0 Split Coil Winding Implementation

QD0 split coil variant may be useful for low-energy running as a Universal Final Focus.



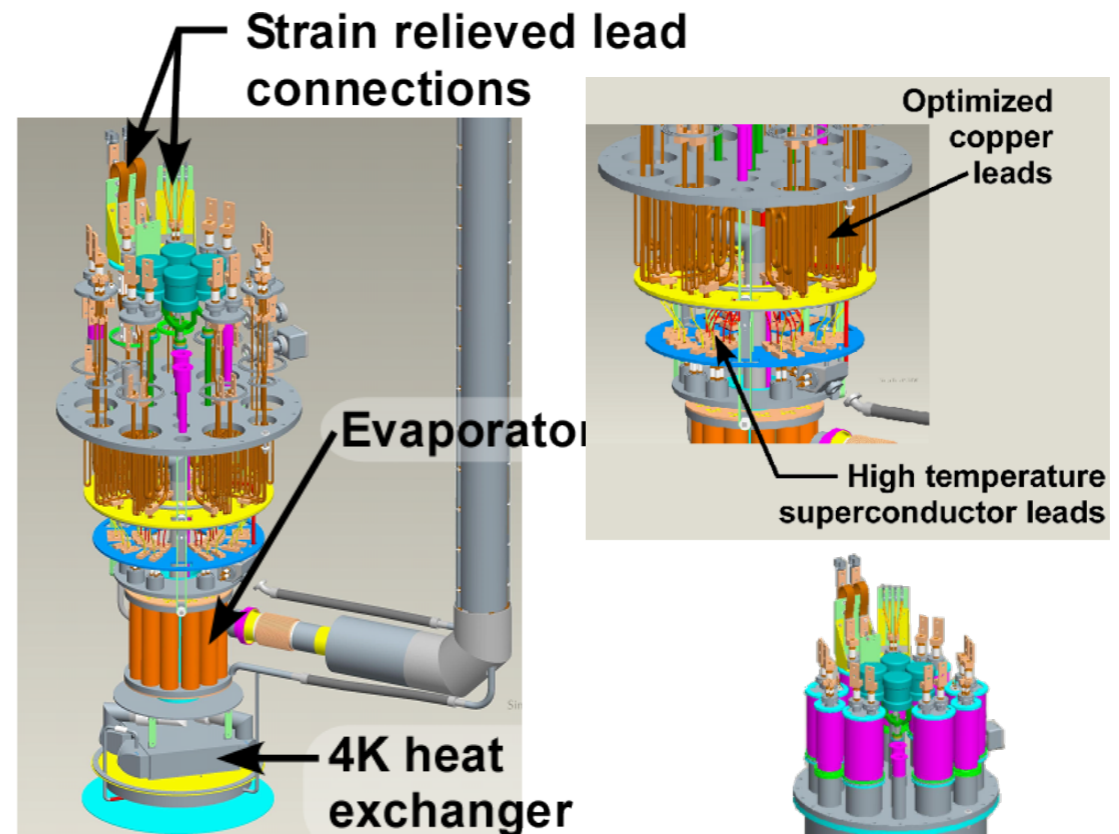
View Inside QD0 Cryostat to Show Coil Positions and Support Infrastructure



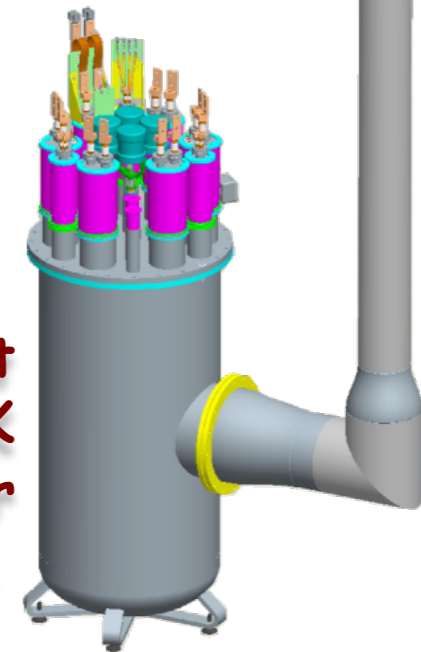
QD0 R&D Tests and 2012 Time Scale

- Parallel to finishing QD0 R&D coil winding we are producing the Magnet and Service Cryostats needed for horizontal testing.
- Look to have operational experience on 2012 (TDR) time scale.
- Recently new ideas were put forth on measuring the field centers & vibrations.
- Also address issues for new Universal Final Focus.

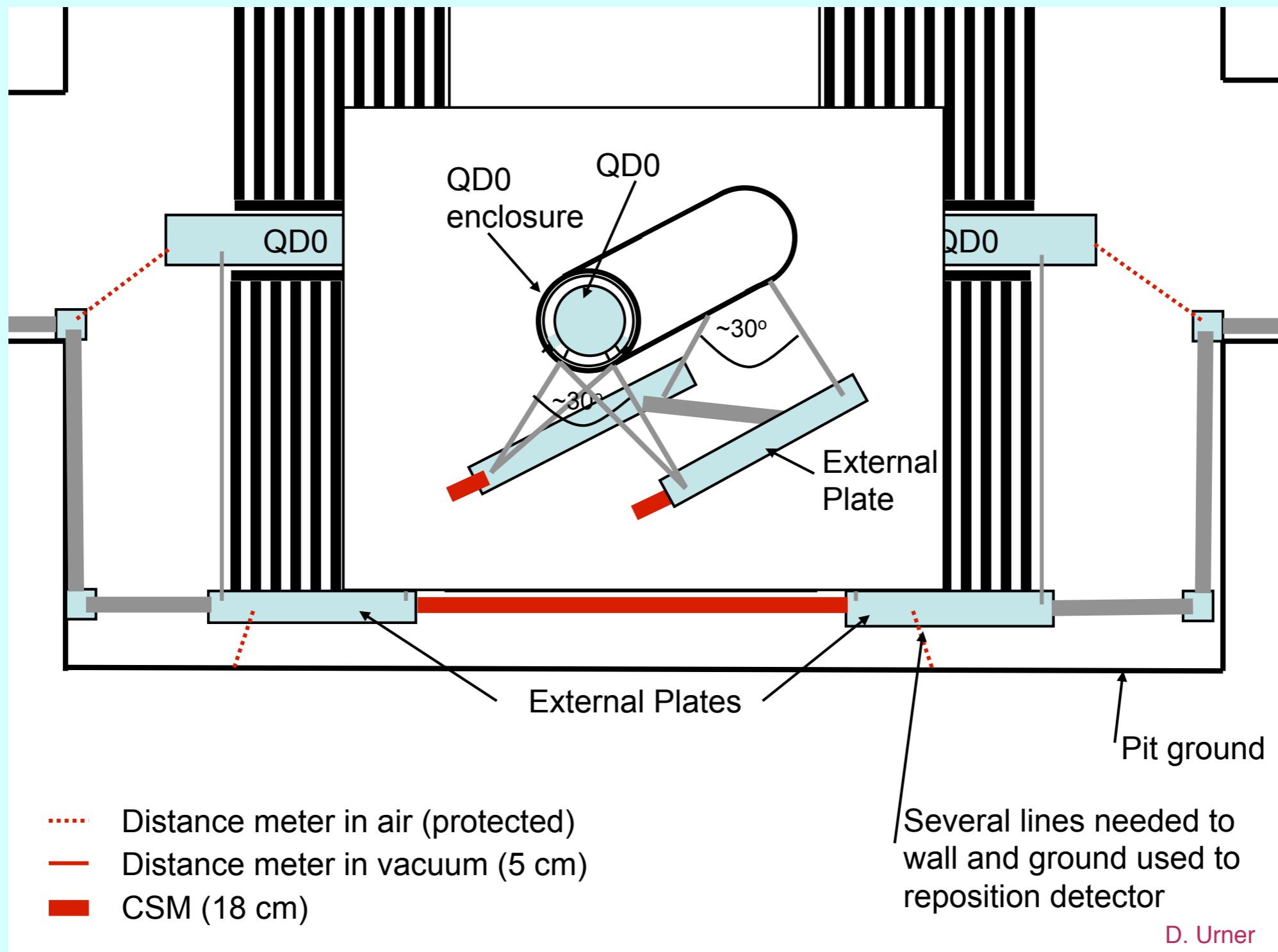
Service Cryostat Under Construction at BNL



R&D Goal: Make and test Service Cryostat with 1.9K cryogenic transfer line for ILC-like running conditions.



- Conceptual studies to use an interferometric laser system for alignment of QD0 and detector parts:



MDI Alignment at CLIC

• CLIC requirements:

- Position of QD0 w.r.t BDS: $\pm 10 \mu\text{m rms}$
- Monitoring left QD0/ right QD0: $\pm 5 \mu\text{m rms}$

• ILC requirements:

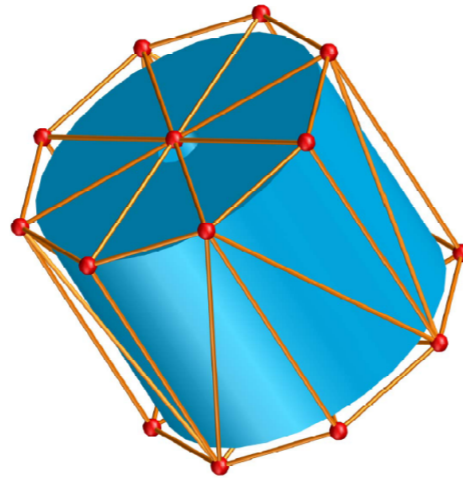
- $\pm 50 \mu\text{m}$ for QD0s before beam-based alignment

• Synergies obvious



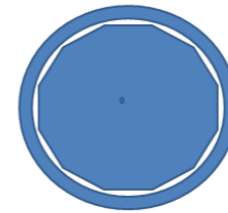
Monitoring of QD0:

- Network of over-determined nodes linking each QD0
- Each node consists of a combination of RASNIK systems performing measurements through the dead space between polygons and circular detector areas
- RASNIK systems calibrated with a sub-micron accuracy
- This project is part of a collaboration with NIKHEF institute.



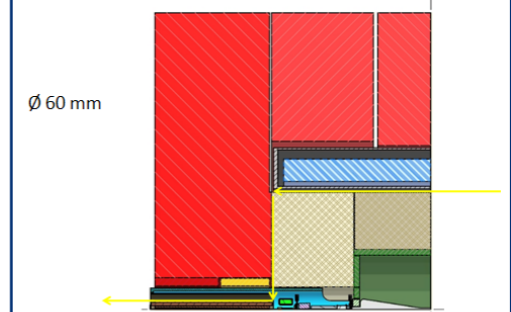
Alignment channels

- Typically use 'dead' space between polygons and circular detector areas



H. Gerwig - 11th MDI meeting

Preferred alignment channel



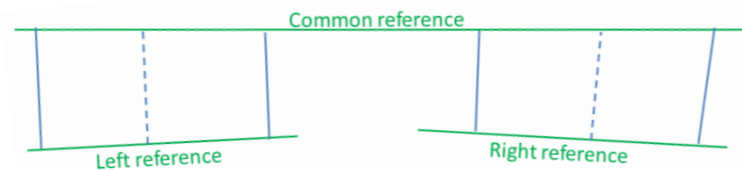
H. Gerwig - 11th MDI meeting

Left side w.r.t right side

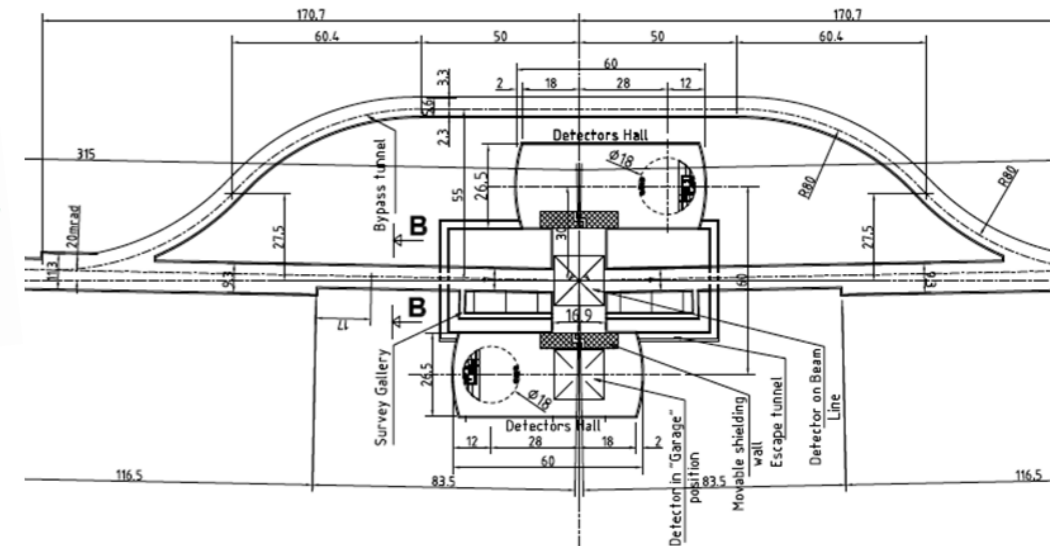


Monitoring of one BDS w.r.t other

- Link stretched wires on both side by a common references (like in the LHC), using the survey galleries

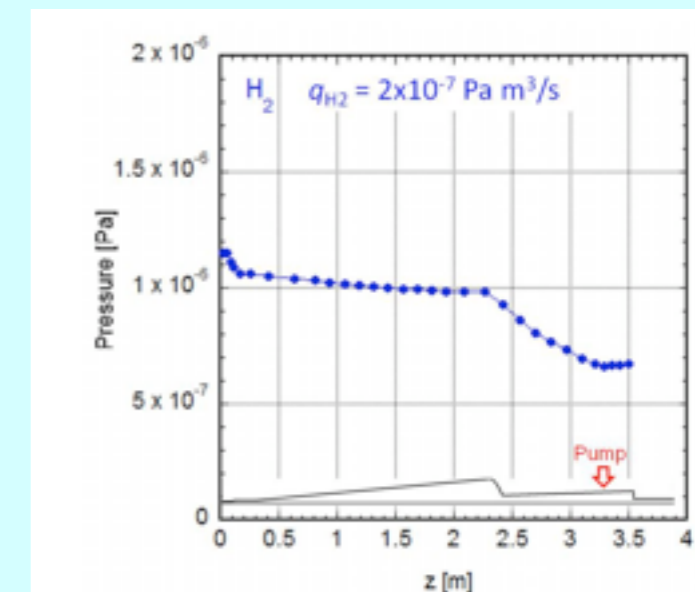
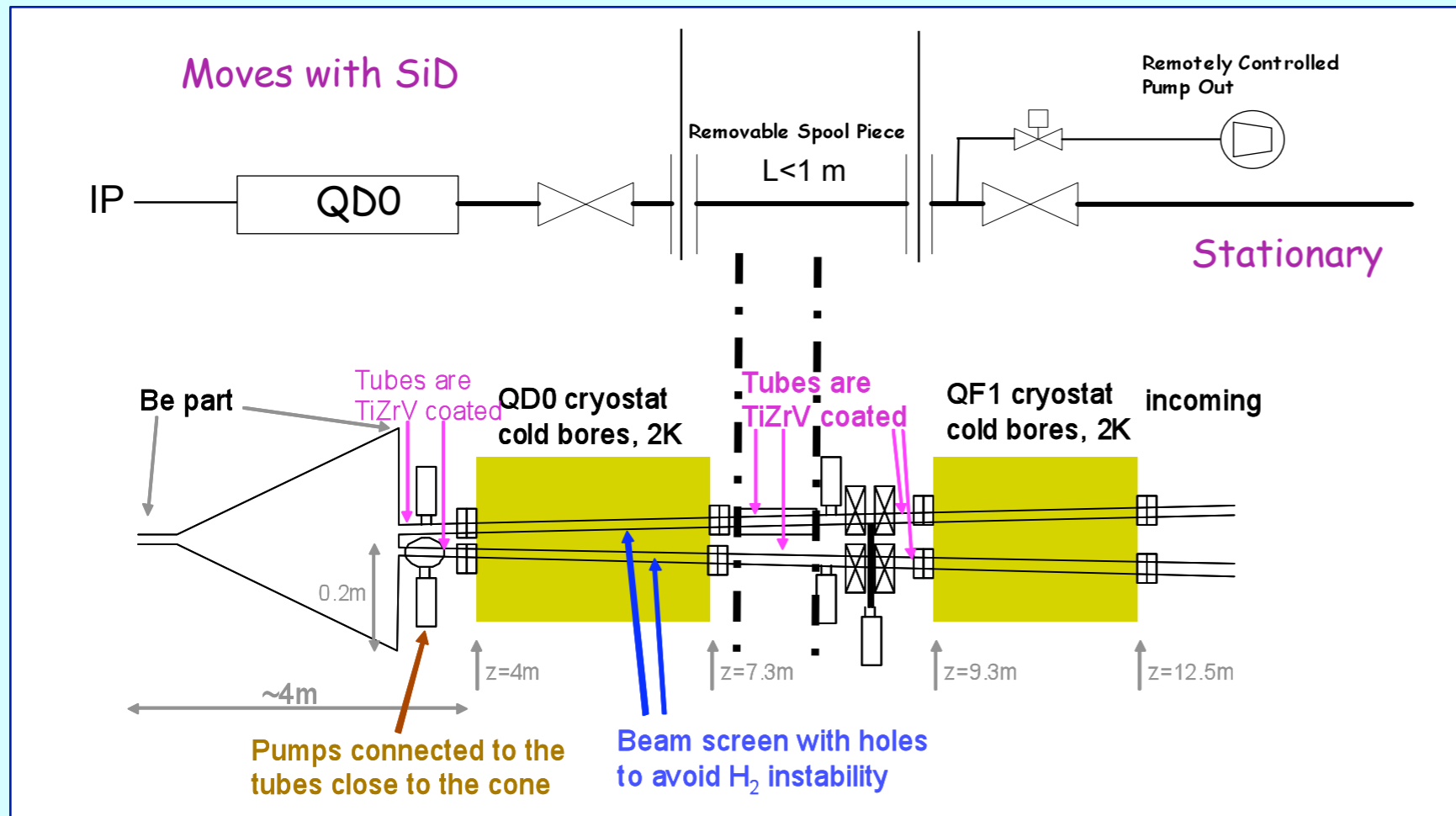


H. Mainaud-Durand

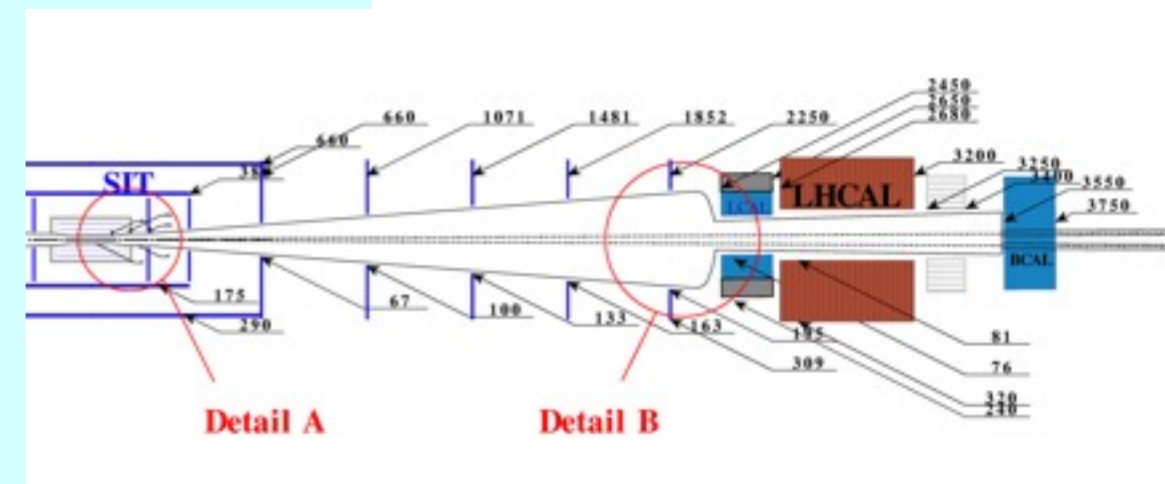


Vacuum System Design

- Vacuum up to the valves between QD0 and QF1 will be provided by the BDS ($<10^{-9}$ mbar)
- Vacuum downstream of these valves is the choice and responsibility of the detectors



- ILD beam pipe conceptual design:
 - Made from beryllium (8kg mass in total)
 - Vacuum simulation study done, 10^{-9} mbar will be difficult to reach

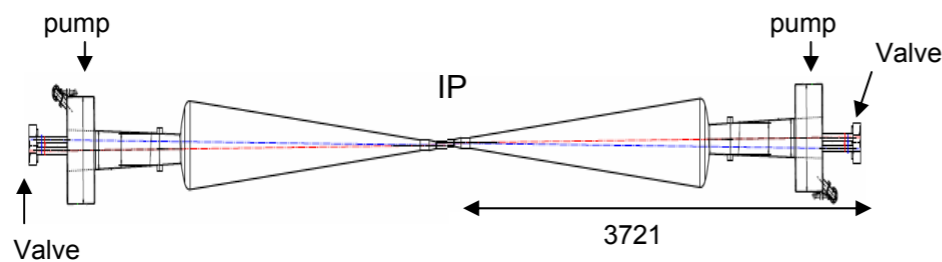


- Example ILD:

VACUUM DISTRIBUTION ON ILD

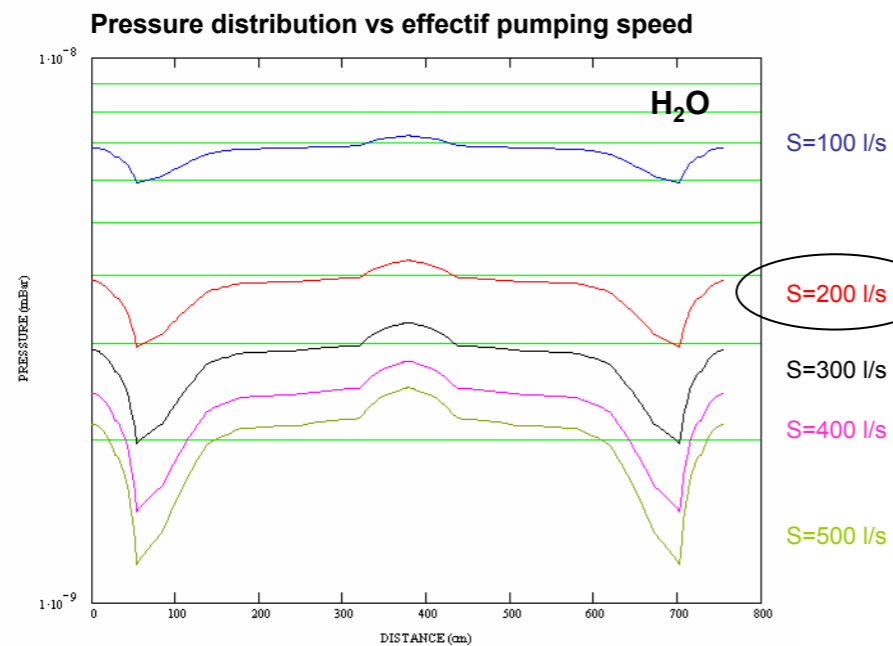
UNDER STATIC CONDITION

WITHOUT BAKING



For Al, SS or Cu after a classical cleaning and ~ 100 h pumping

$$\tau(\text{H}_2\text{O}) \approx 2 \cdot 10^{-11} \text{ mbar.l.s}^{-1} \cdot \text{cm}^{-2}$$



What pumping?

Annular triode ion pump from LHC

15 cells 18 l/s(N_2) nominal, $\varnothing_{\text{int}} = 62$ $\varnothing_{\text{ext}} = 200$ $L = 25,4$



Optimized annular triode pump for experimental areas in the LHC M. Busso and all, LHC Project Report 670

With ≈ 200 cells



M. Joré

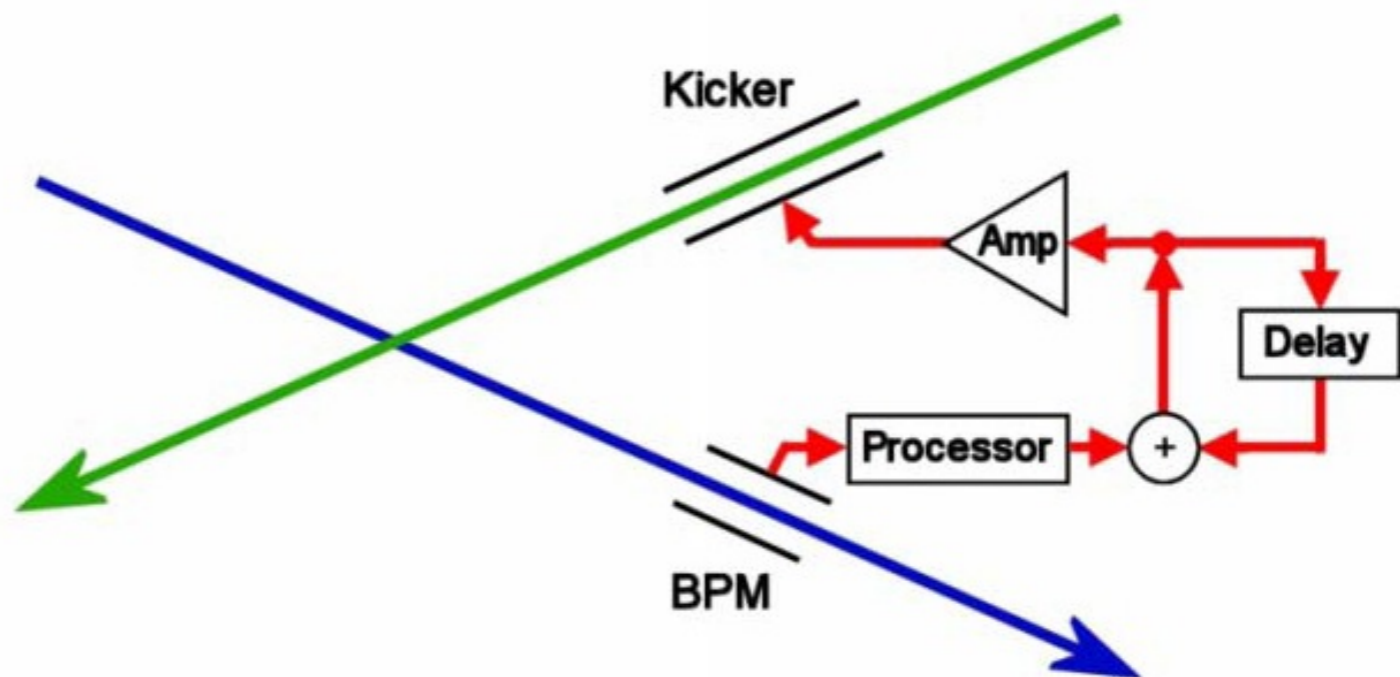
IR Feedback System Design

IP intra-train feedback system - concept

**Last line of defence
against relative
beam misalignment**

**Measure vertical
position of outgoing
beam and hence
beam-beam kick
angle**

**Use fast amplifier and
kicker to correct
vertical position of
beam incoming to IR**



FONT – Feedback On Nanosecond Timescales

(Oxford, Valencia, CERN, DESY, KEK, SLAC)

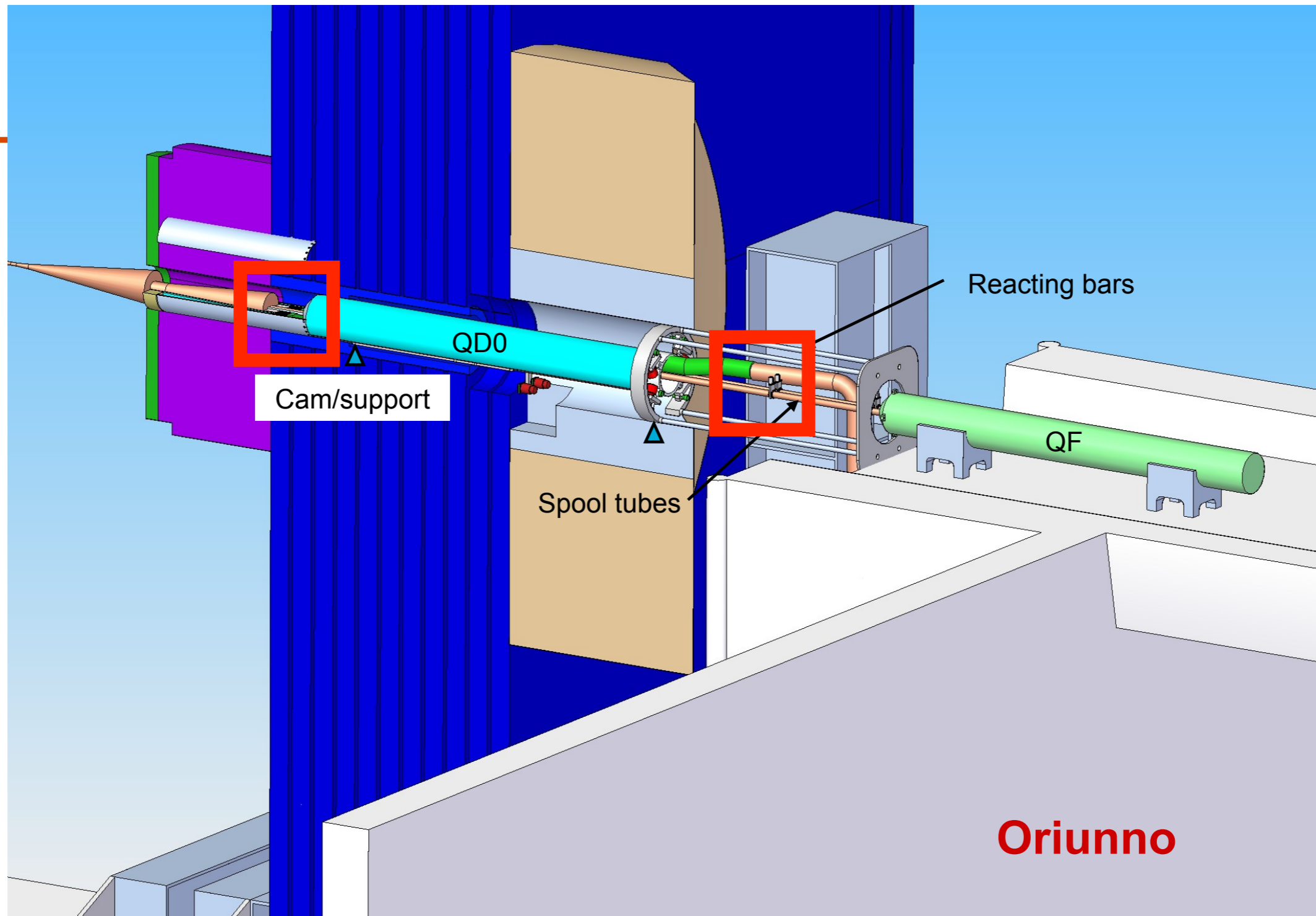
Philip Burrows

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P. Burrows

Final Doublet Region (SiD for illustration)

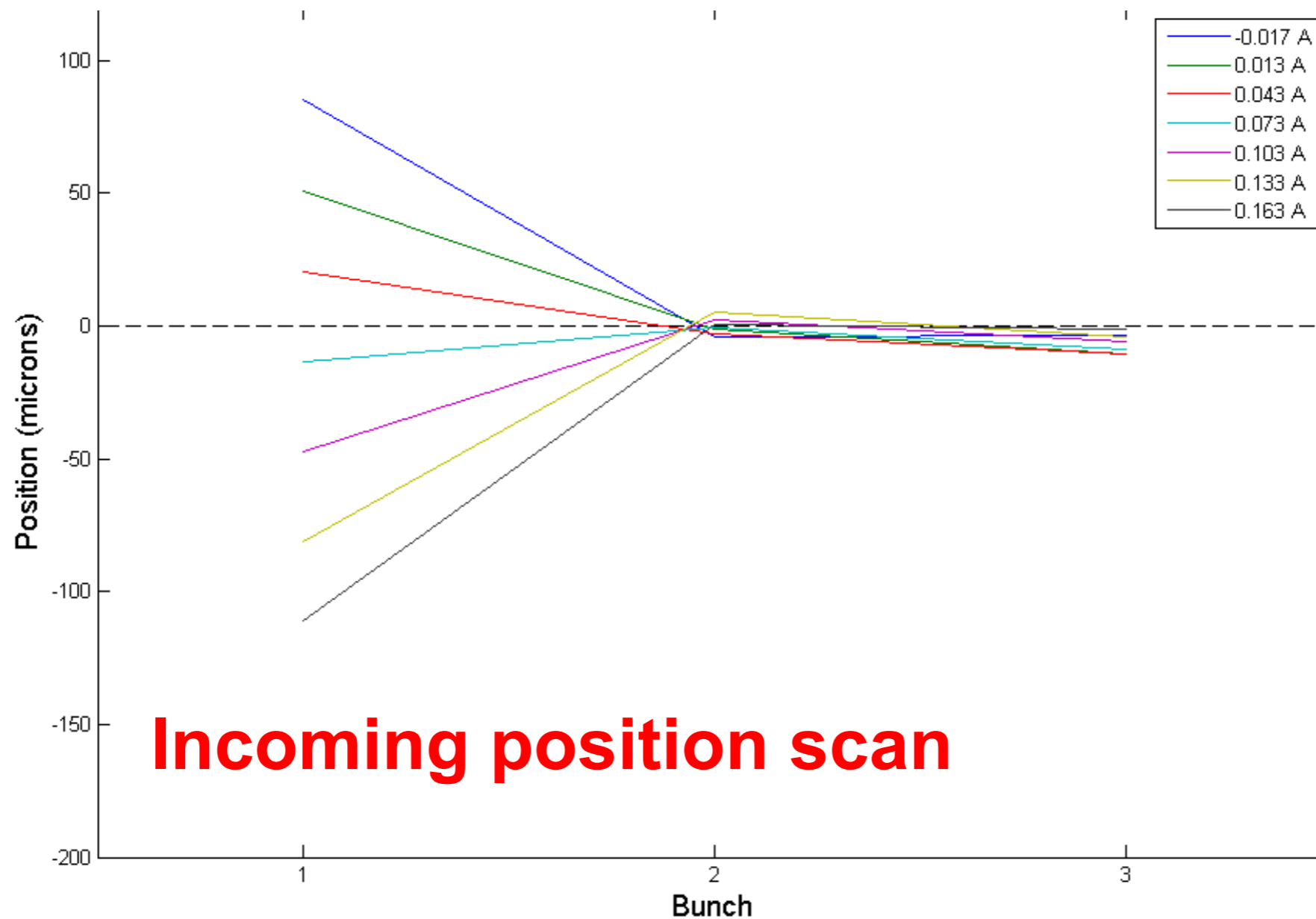


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P2 → K1 loop performance (February 2010)



- Machine-Detector Interface work is concentrating mainly on a design study plan for a realistic push-pull system for ILC
 - Many related topics and technical issues need to be studied to some engineering detail
 - Most urgent decision is the choice of a common detector motion system
 - Engineering resources are very limited, ILCSC has offered help to find more
 - Synergies with CLIC will be exploited
-
- Thank you!